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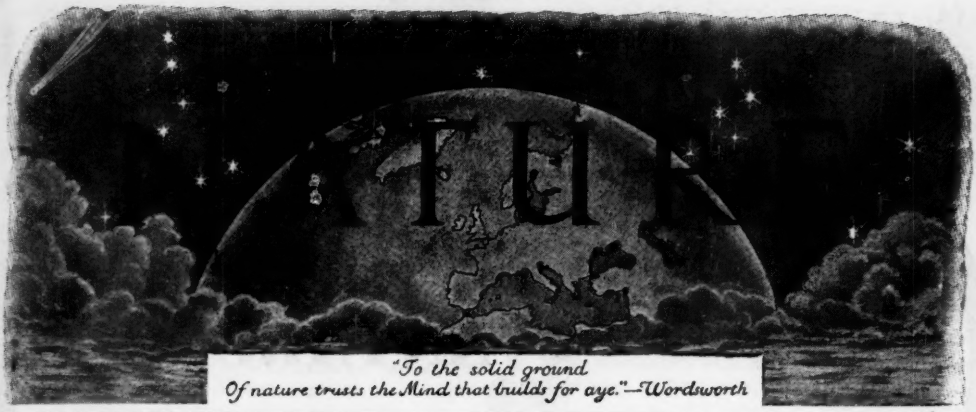

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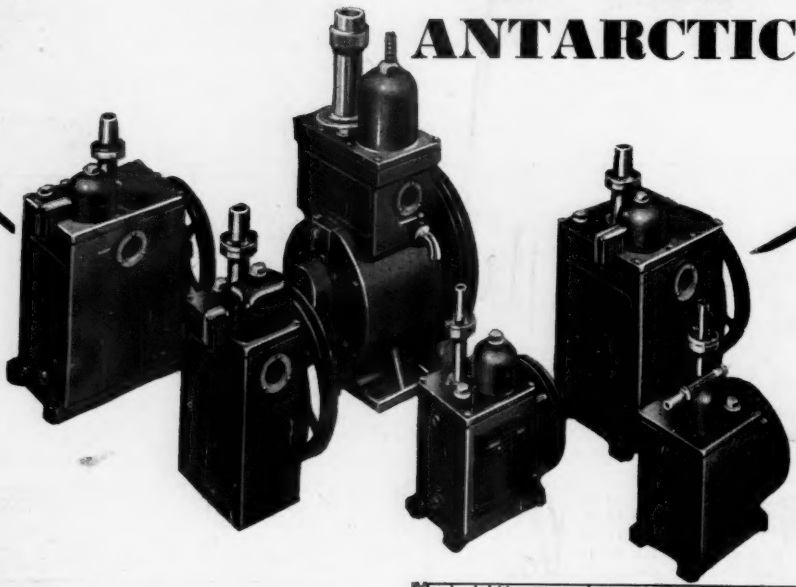

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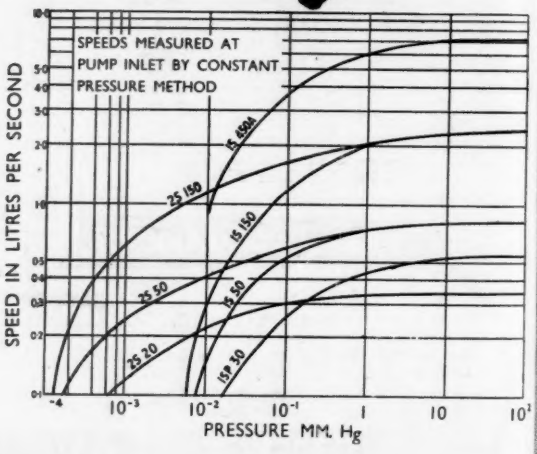

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SCIENCE AND THE LAYMAN

TWENTY years ago, at its centenary meeting in London in 1931, and again in returning to the scene of its first meeting in York in 1932, the British Association, both in the presidential addresses and in the proceedings of the meetings, looked back over the progress of science during the previous century, and in particular at the way it had assumed an increasingly important place in the life of the community. The annual meeting of the Association remains to-day, however, what it has been from its earliest years—the principal public forum in Great Britain for the review and general discussion of progress in all branches of science. The meeting in Edinburgh is thus appropriately regarded as part of the Festival of Britain, which aims at displaying the British contribution to civilization in the arts, in science, and in industrial design.

The Council of the Association decided at an early stage, accordingly, that it would be fitting for the programme of this 1951 meeting to include reviews of progress during the past century and, without substantial alteration to the normal character of the programme, some twenty reviews of progress in particular topics are being presented at this Edinburgh meeting. The presidential address of H.R.H. the Duke of Edinburgh, which is printed on p. 219 of this issue, reviews the British contribution to science and technology in the past hundred years, and what is worth noting here in the first place is that while the other addresses, like the presidential addresses at London and at York, are by men of science, the president disclaims any such title. At the outset he insists that he addresses the Association as a layman, and that his review is an endeavour to give an impression from outside of the march of science in the past hundred years and of the community's appreciation of the work of scientific men and women. But he is too modest in his estimate of his own claims to address the Association: his professional training in itself involves some elements of technology, if not of science; and it is manifest from this address that the President's appreciation and understanding of the outlook and achievements of science are in no way inferior to those of the Prince Consort, who occupied the presidential chair at Aberdeen in 1859. The Duke of Edinburgh in his address has ranged over a variety of subjects in science and technology, infinitely more complex than those displayed to his great-great-grandfather, and touched them with a discrimination and balance that few of the numerous addresses of a similar kind delivered during the present year have approached.

That may indeed be one justification for one who claims to be a layman addressing the Association from its presidential chair, and if, as the Duke of Edinburgh suggests, the very invitation demonstrated that science is not a magic circle, his address should help further to dispel the idea that science and technology are magic or mysterious activities apart from the ordinary activities of men and women and beyond their comprehension. In the modern world, such an impression is highly dangerous to the con-

tinuance of science, and, at a time when in Great Britain and in other countries the prosecution of scientific research depends more and more on public funds for support and less on private benefactions, it is of first-rate importance that the nature of scientific work should be clearly and widely understood.

The contribution of the Duke of Edinburgh's address to such a wider understanding is of real service to science. Besides this, in reviewing the implications of the British contribution to science in the past century and the lessons to be learnt from those achievements, he emphasizes some of the factors upon which continued advance depends, and indeed the economic prosperity of the British people. This part of his address is reminiscent of Sir Henry Tizard's presidential address at the Brighton meeting of the Association, from which indeed he quotes; but even more than his review of the past, it bears the new President's distinctive imprint, and some of these warnings of the layman are not to be disregarded.

The Duke of Edinburgh recognizes to the full, for example, the value of co-operation and team-work in science and the way in which, with the growing complexity of research and the mounting cost of equipment, scientific and technical advance depends on such equipment. None the less, he points out that the basic discoveries which mark the great advances depend on the accident of individual genius, and it would be disastrous if no place were left for the individual investigator working in his own laboratory. Scientific discovery, in fact, only flourishes where it finds the right conditions, and of these the social climate is one of the most important. That is manifestly appreciated by the Duke of Edinburgh, though he obviously could not point to the risk of political climate discouraging initiative and enterprise. For example, it has been stated recently that the benefits of chemical industry, which has contributed so much to medical advances and the relief of suffering, might well cease to flow in the absence of competition and that new remedies might never be developed for the public benefit because of the disturbance involved to existing products. Only an alert and informed public opinion can prevent such dangers and ensure the social and political climate in which science and technology thrive.

The President is clearly aware of the vital importance of educating public opinion in all such matters, and if he spoke as a layman and amateur, it is well to be reminded that laymen and amateurs have still important contributions to make to science. Indeed, it may be questioned whether there can be any really wide understanding of what science is and how it works, save in so far as members of the community participate in some scientific activity at least in an amateur capacity. So long as they are based on a clear understanding of scientific principles and the method of science, the activities of the amateur photographer, the radio amateur, the bird watcher and many others all contribute to that end; the great value of the field-work which is now receiving increasing attention is that it teaches students of a wide range of types how to pursue open-air activities which appeal to them in a scientific way.

Such work, quite apart from fresh observations to be added to the store of scientific knowledge, is of great value and is to be welcomed as assisting in turn the wider understanding of what science is. In its way such educational work is fully as important as the finding of a solution to the problem of higher technological education to which the Duke of Edinburgh specifically refers. Here, and elsewhere, his address indicates problems requiring urgent attention, and he need be in no doubt that the scientific men in Great Britain will find his address as stimulating as it is full of interest. But above all, it is to be welcomed as a fresh demonstration that the layman and amateur, using that word in its fine original sense, have a vital contribution to make in furthering mutual understanding between the man of science or technologist and the citizen; an understanding which is essential both for the furtherance of the conditions in which creative scientific work can flourish and for the application of scientific knowledge for the benefit of mankind.

FIFTY YEARS OF PROGRESS IN SCIENCE

Scientific Thought in the Twentieth Century

An Authoritative Account of Fifty Years' Progress in Science. Edited by Prof. A. E. Heath. Pp. xv+387. (London: Watts and Co., Ltd., 1951.) 42*s*. net.

THIS book is a number of essays by thirteen authorities on their respective branches of science with an introduction by Prof. A. E. Heath, which is followed by a chapter on the philosophy of science by Prof. A. J. Ayer. The contributors are Prof. R. A. Fisher on statistics, Sir Harold Spencer Jones on astronomy, Prof. F. Llewellyn Jones on physics, Dr. Andrew Kent on chemistry, Prof. Duncan Leitch on geology, Prof. P. B. Medawar on zoology, Dr. E. B. Ford on genetics, Dr. J. C. Hawksley on general medicine, Dr. Alice Stewart on social medicine, Dr. Derek Richter on neurology, Sir Cyril Burt on psychology, Prof. Meyer Fortes on social anthropology and Donald G. Macrae on sociology. The editor and publishers are to be congratulated on bringing together the work of such a galaxy of men of science; this in itself is indicative of the quality of the book.

Nevertheless, each author seems to have been restricted to a mere 7,000–9,000 words. Some of the writers have the gift of putting a quart, or often a gallon, into a pint pot, others clearly have felt themselves to be unduly hampered by lack of space; but without exception an outline, albeit sketchy, of a half-century of progress in their respective subjects has been clearly and faithfully presented. It would appear unfair to single out a particular essay as outstanding, but Prof. R. A. Fisher's contribution seems to be particularly useful, in that he explains the nature of certain tools of research which he himself has helped to forge, and which have been so useful in the development of the biological and social sciences, described by some of the other contributors. Fisher sums up his position thus: "In the present century we have learnt (i) to conserve in its statistical reduction the scientific information latent in any

body of observations, and (ii) to conduct experimental and observational inquiries so as to maximize the information obtained for a given expenditure".

It is strange that there is not a chapter on botany, especially as that on genetics only deals with the vegetable kingdom in the early paragraphs on Mendel. It is pleasing to find essays on social medicine, social anthropology and sociology in such a work as this; but as there is a separate chapter on neurology, why not one on bacteriology and another on physiology? Two only of the later chapters have bibliographies, though Sir Cyril Burt supplies useful footnotes instead. In view of the brevity of each essay, it would have been valuable had indications for further reading been supplied by every author.

The book jacket claims that the work is intended for the "general reader". The reviewer has some difficulty in picturing this general reader. Is he a reader with some scientific background or is he the intelligent 'man-in-the-street'? Have men of science yet been able to appreciate his mental processes? The problem arises when such splendid passages as the following occur in the work: "Other basic principles which have been suggested are Milne's *Principle of Impotence*, that one cannot tell where one is in the universe, and Bondi and Gold's *Perfect Principle*—that one cannot tell the cosmic time. Older principles, such as that of the conservation of energy, turn out to be trivial consequences of these principles"; or again, in another section, "T is a consistent estimate of a parameter θ if in large samples it converges in probability to the limit θ".

The painter Whistler said that his work was not to be valued at so much a square foot but in terms of the experience of a life-time. The same principle seems to apply to the present book, which costs two guineas. It is difficult not to recall the spacious days between the Wars when Mr. Gollancz was able to produce a larger and more comprehensive volume, with five or six times the amount of material of the present work, for the modest price of five shillings.

W. L. SUMNER

A PHILOSOPHER'S PHYSICS

Essays in Physics

By Viscount Samuel. Pp. vi+154. (Oxford: Basil Blackwell, 1951.) 7*s*. 6*d*. net.

AN 'event' has become a familiar word in philosophical literature, and for a variety of reasons. In the hands of the late Prof. A. N. Whitehead it achieved an almost æsthetic connotation among scholars. Now, the appearance of a set of essays by Lord Samuel is assuredly an event and, moreover, one to be pondered over and welcomed. Writing with the dignity and charm of an elder statesman, this slender volume of his resembles a subtle kind of tonic, to be taken with care, and perhaps not always without obtaining a prescription for it beforehand.

With justification, the author is scarcely enamoured of the tendency to confuse concepts of the mind with physical realities, and he complains that the present-day physics tends to blur the issue. The difficulty here is that Lord Samuel is an incorrigible optimist (a welcome enough quality these days), firm in his belief that there is in very truth a sharp boundary upon which to focus. It is conceivable, however, that, at any rate for some time to come, we may have to put up with a species of mental moratorium, not in a mood of despair, but as an honest facing of the facts. All of which suggests that some bold thinking along the lines of the late Edmund Husserl's "phenomenological bracketting" (or *epoché*) might provide a finger-post towards the solution of this particular dilemma, more especially in view of the radical *ding-an-sich* attitude inherent in it. Recollecting that Husserl started as a mathematician, and developed into an outstanding exponent of a presuppositionless philosophy, it seems by no means fantastic to propose a thorough search in that difficult terrain for some sort of a solution to this puzzle.

Lord Samuel lists three conclusions, two negative and one "more positive", which have an important bearing. First, the impossibility of measurement must not lead to the assumption of no causes. Secondly, the cause of any event cannot be a mental concept *per se*. (Incidentally, this seems but an echo down the centuries of what St. Thomas Aquinas thought of St. Anselm's views, or something very like it.) Thirdly, and indeed well said, is the need for speculation. Although it seems unlikely that any exception will be taken to these precepts, it is good to have them so aptly formulated.

Much of the remainder of the book is taken up with a discussion of certain lines of inquiry such as waves, particles, gravitation, and so on, followed by some observations upon quiescent energy. Lord Samuel will not expect to gather in a neat bundle of acceptances here; but his outlook is stimulating nevertheless. The collection ends with a letter from Prof. Albert Einstein, accompanied by an English translation; the German *verzicht* rendered as "resignation" is not very happy, but otherwise a sound piece of work. There is a slight misprint on p. 102 (7); but elsewhere the text is above reproach.

If two constructive hints are permissible, one is that Bohr's principle of complementarity might help to clarify some of the more obvious anomalies; the other is that in the concept of 'logical pressure' envisaged by the late Prof. E. A. Milne and exemplified in his epistemological approach to physics, probably lies the best hope of advance for which Lord Samuel so eloquently pleads.

F. I. G. RAWLINS

CHEMISTRY OF PHENOLIC RESINS

Chemie der Phenolharze

Von Dr. K. Hultzsch. (Organische Chemie in Einzeldarstellungen, Band 3.) Pp. vi+193. (Berlin, Göttingen und Heidelberg: Springer-Verlag, 1950.) 19.60 D. marks.

THE technical importance of phenolic resins and their industrial exploitation have not been reflected in corresponding fundamental advances. Until the late 1930's, investigations on the basic structure of the resins were comparatively few and their results were often inconclusive, chiefly because of the complexity and difficulty of the problem. The position was markedly altered by the work in Sweden, Germany and Austria carried out by the schools of Von Euler, Hultzsch and Zinke, so that at the present time a considerable amount of relevant information has been accumulated. Whereas earlier investigators largely used the analytical method—that is to say, they attempted to break

down resins into identifiable crystalline compounds—the Continental work has been mainly of a synthetic type involving identification of materials produced during resinification of such active compounds as phenolic alcohols.

Dr. K. Hultzsch's book is the first real attempt to correlate the available information. It constitutes an effort to review critically and comprehensively the considerable literature and diverse views accumulated over many years. Dr. Hultzsch has included a historical survey, an account of the condensation of phenols with aldehydes and other compounds on the basis of modern electronic ideas, a critical review of existing chemical knowledge, and chapters on the technology of a wide range of phenolic resins and on their testing. The book includes author and subject indexes, as well as 376 separate references to papers published up to 1948. Comparatively little of significance has been omitted, although a few papers of perhaps minor importance appear to have been overlooked. If the chemist has been catered for more fully than the technologist, the fact must be accounted a good fault, in view of the practical trend of so many plastics books produced hitherto.

Controversy will still continue on the mechanism of the phenol–formaldehyde reaction despite Dr. Hultzsch's attempt at clarification, while few will agree with his contention that little more now remains to be done on the chemistry of the subject. There is likely to be still greater disagreement with his emphasis on the quinone methide structure as an essential feature of the heat-hardening of phenolic resins; most workers are likely to take the view that the evidence is as yet insufficient. Nevertheless, the author deserves gratitude for stimulating curiosity in a difficult field of work, and his monograph can be recommended unhesitatingly as essential to all workers on polymers, particularly at this time, when the organic approach tends to be neglected in favour of the more popular physico-chemical method of attack.

Students and advanced research workers will equally welcome this publication, so long as they can cope with the none too easy style of German writing adopted by the author. N. J. L. Megson

AN ORNITHOLOGICAL PIONEER

Studies in Bird Migration

Being the Collected Papers of H. Chr. C. Mortensen, 1856–1921. Edited by Poul Jespersen and Å. Vedel Tåning. (Published by Dansk Ornithologisk Forening.) Pp. 272. (Copenhagen: Ejnar Munksgaard, 1950.) 18 kr.

THE method of studying the movements and life-histories of birds by marking them with light metal rings on the feet is now used in many parts of the world and in some of them on a substantial scale; it has yielded results of great value and its possibilities are very far from exhausted. Bird-ringing of a cruder sort had been tried in a small way before; but it was not until 1899 that rings of various sizes with serial numbers and adequate addresses were introduced. This development was due to a Danish schoolmaster, Hans Christian Cornelius Mortensen (1856–1921), whose collected papers on the subject are now republished in an English translation. This suitably marks the jubilee of his pioneer effort; and it also makes more accessible the results of his work, which are still of intrinsic scientific value.

Not many more than five thousand birds were ringed under Mortensen's own scheme (as compared with about one million in the British Isles alone during the past forty years); but he had either the foresight or the good fortune to concentrate largely on interesting species yielding a remunerative percentage of recovery records. Thus, after an initial disappointing experience with ringing starlings on an inadequate scale, he obtained excellent results with the white stork, the heron and various species of ducks, gulls and birds-of-prey.

With the white stork, Mortensen was able to show that those bred in Denmark usually migrate south-eastwards across Europe, around the Levant and through East Africa to the extreme south—but sometimes south-westwards to North Africa. The more numerous records from German and Hungarian ringing have amplified the picture.

More than three hundred pintail caught during autumn migration at a duck-decoy on the island of Fanö, off the west coast of Jutland, were purchased, ringed and released. The recovery records, about 20 per cent of the number of birds ringed, showed that ducks of this species passing through Denmark in autumn come from a summer area which extends to northern Russia as far as the White Sea and the Arctic Ocean; and that in winter they reach the British Isles, Holland, France, Spain, Italy and the eastern side of the Adriatic Sea. This finding still stands for comparison with results obtained from subsequent ringing elsewhere, and it forms an essential part of the general picture that is being built up of the seasonal movements of the pintail.

Reconciled as one is to recovery-rates as low as a fraction of one per cent for small passerine species, one may well be envious of such figures as 28 recoveries out of 65 ringed in the case of the common buzzard, and 10 out of 13 in the case of the goshawk. These spectacular rewards for a relatively small effort showed the value of the method, although with the less remunerative species similar information can be acquired only gradually by organized ringing on a scale of which the pioneer possibly did not even dream. A. Landsborough Thomson

THEORY OF FUNCTIONS

Funktionentheorie

Von Prof. Constantin Carathéodory. (Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften: Mathematische Reihe, Bände 8 und 9.) Band 1. Pp. 288. 36 Swiss francs. Band 2. Pp. 194. 24.50 Swiss francs. (Basel: Verlag Birkhäuser, 1950.)

THE title of this work is perhaps a little misleading, as suggesting a treatise on all the main aspects of the theory of functions; but it would be unreasonable to expect, even in two volumes, a full account of such an extensive subject, which can be approached in several different ways. Cauchy's method was based on integration around a contour, Riemann's on intuitive ideas derived from physics and geometry, and Weierstrass's on the power series.

All these dealt with the complex variable. Later came Cantor's theory of sets of points, leading to a great development of the theory of functions of a real variable. The name of Carathéodory is familiar to mathematicians as the author of a masterly treatise on the real variable. But the work under review is of quite a different nature; it can be described roughly as an introduction to a modern version of Riemann's geometrical ideas, freed from their original weaknesses, so that this approach can now be considered as firmly founded as the Weierstrassian. The main supports of this new version are Schwarz's theorems on conformal representation and Montel's concept of normal families of functions. These are used in conjunction with several modern developments, some due to the author himself, to give a clear and attractive exposition of fundamentals, though not including the general theory of Riemann's surfaces, of algebraic functions, or of uniformization. Although designed primarily as a text-book for students, some parts will be new and interesting even to the expert. The author died before it was published; but he had the satisfaction of seeing all the proofs, and his failing health would never have been suspected from the polished excellence of the work.

The division of the work into two volumes of unequal size, which is stated to be for the convenience of students, does not correspond to any real break in the continuity of the argument, and must have added to the cost of the work, which, at the present rate of exchange, is very high indeed in Great Britain. The first volume is divided into five parts, and the second volume into two more parts; each part is subdivided into three or four chapters. The first part begins with complex numbers, but takes an unexpected turn with the transition to spherical and non-Euclidean geometry. Emphasis is laid upon Ostrowski's *chordal difference* of two complex numbers, which is much used in the later pages, as it enables the point at infinity to be treated on the same footing as ordinary points. The second part gives a brief enunciation of such parts of the theory of sets of points as are needed in the later pages; for proofs the student is referred to the author's "Reelle Funktionen". The third part deals with analytic functions, including Cauchy's theorem, the maximum-modulus theorem, Schwarz's lemma, Poisson's integral, harmonic functions and meromorphic functions. The fourth part deals with the generation of analytic functions by limiting processes, using the somewhat unfamiliar ideas of *continuous convergence* and *limit-oscillation* to treat normal families of functions. These modern ideas precede the much older theorems of Taylor, Laurent, Mittag-Leffler, and a very brief treatment of the calculus of residues. The English-speaking reader may be puzzled why books in his own language contain so many examples, worked and unworked, on these topics, while Carathéodory's book contains none. The fifth part deals with some special functions, namely, the exponential and trigonometrical functions, the logarithm and general power, the gamma function, and Bernoulli's numbers.

Turning to the second volume, the sixth part begins with a discussion of functions the moduli of which in a certain domain do not exceed unity, and in particular those of which the moduli are equal to unity at every point on the circumference of a circle of unit radius. After the important theorems of Pick, Jensen, Julia, Lindelöf, Fatou and Riesz, the way is clear for a rigorous treatment of conformal representation. The seventh and last part opens with analytic functions of two or more variables and some existence theorems on differential equations. It then applies the conformal transformation of a triangle, the sides of which are circular arcs, to deal with the hypergeometric function and its differential equation. Next come the Schwarzian triangle-functions and the modular function. Finally, there is a discussion of essential singularities and the theorems of Landau, Schottky, Picard and Montel.

The work is beautifully printed, as well as beautifully written, and may be warmly commended to those who can afford to buy it.

H. T. H. Piaggio

THEORY OF PROBABILITY AND STATISTICS

Introduction to the Theory of Probability and Statistics

By Prof. Niels Arley and Prof. K. Rander Buch. (Applied Mathematics Series.) Pp. xi+236. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 32*s*. net.

THIS work is a translation (with a few alterations and additions) of the third Danish edition of a book which has already proved very successful in the country of its origin. For the most part, the translation has been carried out very well.

The two authors are well known for their achievements in different branches of the subject: Niels Arley has made important advances in the theory of stochastic processes and in its application to the problems of cosmic radiation, and K. R. Buch is best known for his work on the range of values assumed by a measure-function on an abstract space. When a physicist and a pure mathematician join forces, the outcome is sure to be interesting; in this case it is a highly individual book which should do good work in familiarizing students of the natural sciences with the ideas, notations and techniques of the modern theory of probability. Its excellence as an introductory text-book for physicists may be illustrated by mentioning that Poisson's distribution makes its first appearance in connexion with the Poisson process (stochastic processes in general appear on p. 48, and the ergodic theorem four pages later). No attempt is made to burden the book with proofs of the central-limit and allied major theorems; but their substance is sufficiently indicated, and the reader is given an accurate and clear picture of what can be expected from the mathematical theory. He will, if serious in his intentions, find this a useful introduction to a detailed study of the more comprehensive work by Feller.

As a text-book on statistics as opposed to probability theory, I found the book much less satisfactory, and it is perhaps a pity that a third collaborator was not found to prepare the 'Fisherian' chapters. For example, there is no mention of the analysis of variance, of the χ^2-test for 'goodness of fit' or of two-by-two contingency tables. In a subsequent edition there is much that could be done to improve these sections of the book; the first half is so good that such an improvement would be well worth while.

David G. Kendall

Elsevier's Encyclopædia of Organic Chemistry

Edited by F. Radt. Series 3: Carboisocyclic Condensed Compounds. Vol. 12B: Naphthalene, A, Compounds containing One Naphthalene Nucleus; Oxo-Compounds (except Quinones). Pp. xxxv+2189–2716+Ind. 62. (New York and Amsterdam: Elsevier Publishing Co., Inc.; London: Cleaver-Hume Press, Ltd., 1950.) £14 to subscribers to whole work.

THIS fourth part of Vol. 12B takes the naphthalene section of the "Encyclopædia" a stage further (see *Nature*, **167**, 916; 1951). It is characterized by the customary excellence of production and freedom from error, and is concerned with aldehydes and ketones containing a naphthalene or hydronaphthalene nucleus. The various compounds are catalogued and their physical characteristics, methods of preparation and chemical reactions are discussed in the stereotyped way. Many of the compounds included in this part are in the nature of intermediates, without great intrinsic interest, and there is perhaps less to appeal to the reader generally interested in organic chemistry than in some of the preceding parts. There are, however, some interesting accounts of the sesquiterpene ketones, such as eremophilone and the cyperones, of the α- and β-tetralones, and of the stereoisomeric α- and β-decalones and their derivatives. The ketonic derivatives of the various hydronaphthalenes are rather scattered throughout the volume, and the tabulated summaries of these given at the beginning will facilitate rapid reference.

Apart from these ketohydronaphthalenes, most of the compounds treated in this part are, of course, compounds in which the carbonyl function is not an integral part of the naphthalene nucleus, but forms a separate attachment. There are, for example, the α- and β-naphthaldehydes and their derivatives, and the various groups of naphthyl ketones, including diketones in which the carbonyl groups are either present in a single side-chain or in two substituents. Included in this volume are the non-enolizable *gem.*-substituted derivatives of the ketonic forms of the naphthols, especially those formed from 1-substituted-2-naphthols. The production of such ketones is a warning against too sweeping generalizations in theories of aromatic substitution. J. W. Cook

The Solidifications of Castings

A Review of the Literature. By R. W. Ruddle. (Institute of Metals Monograph and Report Series, No. 7.) Pp. 116. (London: Institute of Metals, 1950.) 10*s*. 6*d*.

IMPERFECTIONS present in castings or ingots persist, at any rate in large measure, despite any heat or mechanical treatment to which the metal may afterwards be subjected. It is therefore in the highest degree desirable that the factors which control the original solidification of the metal should be understood. Even to-day the production of castings is in large measure a matter of trial and error, combined with traditional experience.

In recent years, however, much attention has been paid to the scientific aspects of the problem, both on the empirical and fundamental sides, and the object of this monograph is to provide a critical review of the existing literature. Part 1 covers, in a general way, the work which has been done towards the practical application of scientific principles; the importance of directional solidification is discussed, and the means available to attain this end are considered. In Part 2 a review is given of the more fundamental work concerned with the rate of abstraction of heat and of solidification, and, although at the moment mathematical analysis has probably yielded results of less importance when applied to non-ferrous castings than to steel, possibly due to the longer freezing ranges, it can, in conjunction with experimental methods of studying the problem, be of undoubted value. The researches discussed in Part 2 and the conclusions drawn therefrom are briefly summarized in Part 3, and an appendix provides details regarding the thermal properties of metals and of the materials from which the moulds are made.

This review, prepared originally for the British Non-Ferrous Metals Research Association, fully upholds the high standard now expected from the Monographs of the Institute of Metals, and the author is to be congratulated on a most useful piece of work excellently carried out. F. C. Thompson

Scientific and Learned Societies of Great Britain

A Handbook compiled from Official Sources. 57th edition. Pp. 228. (London: George Allen and Unwin, Ltd., 1951.) 30*s*. net.

AFTER a lapse of eleven years the compilation of "Scientific and Learned Societies of Great Britain" makes a welcome return to take its rightful place on the easily accessible shelf among other reference sources of British scholarship and learning. This handbook was previously known as the "Year-book of Scientific and Learned Societies", and under that name it has been published, almost continuously for more than fifty years, by Charles Griffin and Co., Ltd., the last issue appearing in 1939. After the end of the Second World War, the British Council acquired the rights of publication and is responsible for editing the present work. If praise be needed, it is sufficient to say that the book is every bit as good as its predecessors.

Part 1 is a new feature of this book and deals with the organization of scientific research in Great Britain. It gives the names and addresses of the main research organizations administered by the Department of Scientific and Industrial Research, Medical Research Council, Agricultural Research Council and the research associations. An interesting chart has been constructed outlining schematically the relationship of the various bodies in Great Britain engaged in scientific research.

Part 2 of the book, which forms about five-sixths of the two hundred-odd pages, is on the lines of the previous issues. It is divided into fifteen sections as follows: general science; mathematics and physics; chemistry; biology and microscopy; medicine; agriculture, horticulture, forestry and veterinary science; engineering and architecture; geography, geology and mineralogy; archæology and history; anthropology and sociology; law; economics, statistics and political science; literature and fine arts; town and country planning and public amenities; other societies. The sections are divided into the regions of London, counties, Scotland, and (where applicable) Wales and Northern Ireland. Within these regional sub-divisions more than six hundred societies are listed alphabetically, giving the objects of the society, principal officers, membership subscription, meeting times and publications.

An index of subjects and names of societies completes the volume.

THE BRITISH CONTRIBUTION TO SCIENCE AND TECHNOLOGY IN THE PAST HUNDRED YEARS*

By H.R.H. THE DUKE OF EDINBURGH, K.G., F.R.S.
President of the British Association

TO mark the opening of this year's meeting, His Majesty The King has been graciously pleased to send the following message :

I shall be glad if you will express to the members of the British Association for the Advancement of Science my appreciation of their having once more honoured a member of my family by inviting him to be their President.

I trust that this year's meeting of the Association will further the development of Science for the benefit of mankind throughout the world, and prove an encouragement to all those men and women who are so devotedly working for that end.

On your behalf I propose to reply in these words :

The Members of the British Association for the Advancement of Science assembled at Edinburgh send Your Majesty their humble duty and their loyal thanks for Your Majesty's Patronage of the Association and your gracious message of encouragement.

I am to assure Your Majesty that the development of Science for the well-being of Your Majesty's Realm and for the general welfare of mankind is the constant object of the Association.

We will strive with all humility and with the grace of God to apply the blessings of scientific and technological improvement to the problems which face us all to-day.

In Aberdeen in 1859 my great-great-grandfather started his address to the British Association with these words :

"Your kind invitation to me to undertake the Office of your President for the ensuing year could not but startle me on its first announcement. The high position which Science occupies, the vast number of distinguished men who labour in her sacred cause, and whose achievements, while spreading innumerable benefits, justly attract the admiration of mankind, contrasted strongly in my mind with the consciousness of my own insignificance in this respect."

I cannot improve on this to express my own feelings ; but, like him, I reflected upon your invitation and came to the conclusion that it is just as an outsider, a layman so to speak, that I can be useful to you and to science. This very invitation seems to me to demonstrate that science is not a magic circle and that you wish us to enter your confidence. In return the least I can do is to show our appreciation of the work of scientists and to give you a layman's impression of the march of science in the past hundred years. I crave your indulgence if I have drawn any false conclusions and I hope that during the meetings which will follow this one, the experts will take the opportunity to make any corrections.

* Presidential address delivered at Edinburgh on August 8.

The Prince Consort had very much less reason to be modest about addressing you than I have, because this year we celebrate the anniversary of the Exhibition which was his greatest achievement, and an event which had an untold value to science. Let us hope that this year's Festival will be judged a worthy successor and an inspiration for the future. I am proud to pay tribute to this man who saw so clearly the part science was destined to play in the future of this country, and my address is largely the story of the fulfilment of his hopes.

The Starting Point

In a review of British science and technology, 1851 is a convenient starting point for two reasons. First, the Exhibition of that year can be regarded as a gigantic stocktaking of the national resources and technical skill ; secondly, because it marked the end of the Industrial Revolution and the conversion of Victorian England to the policy of industrial expansion on which our future still depends. The period as a whole saw the climax of our industrial supremacy and its inevitable decline when countries with greater resources and population learned from us the lessons of the mechanization of industry. It also covers the birth and growth of the new concepts of modern science.

Social conditions of a hundred years ago were, generally speaking, the outcome of the Industrial Revolution, but with all the traditions of the England of agriculture, cottage industry and small market towns. The population of 20 millions was growing fast but still small compared to our 50 millions of to-day. Education was limited to a minority and was almost entirely classical, so the new profession of engineering had to draw its recruits from a different sphere—that of self-educated men. A new wealthy class was growing up in the commercial world to rival the old aristocracy. There was unbounded optimism about the future and ample scope in commerce and industry to attract all intelligent and enterprising men. The number of poor was on the increase and their conditions were deteriorating because, as yet, no social conscience had grown up to replace the patriarchal responsibility of the landowners and master craftsmen.

In the domestic field, lighting was by candle and oil lamps, cooking and heating by coal or wood in ranges or open fires with the consequent enormous waste of energy. Food had to be fresh or crudely preserved, and thus needed to be produced locally. In health and hygiene the figures speak for themselves. In 1851 the infant death-rate was 150 per 1,000 live births compared with 25 per 1,000 to-day. Anæsthetics, antiseptic surgery, biochemistry, tropical medicine, were all virtually unknown or in their infancy. Psychology had not yet achieved independence from philosophy on one hand and physiology on the other.

This was the age of the practical engineer and of processes arrived at by intuition born of experience and by trial and error. Technology was concerned with the application of steam-power, with metallurgy and the working of metals for various purposes, and with the production of machine tools and precision machinery. Men were already turning their minds to other types of engines, and the internal combustion engine was in the process of development.

Scientists, while continuing their search for the secrets of Nature, were beginning to turn their attention to exploring the empirical developments of industry. Their numbers as yet were small, the endowments for research were negligible and much of their work was carried out in the watertight compartments of the different sciences. But the seed had been sown, and it was not long before scientists and engineers were preparing the way for the great technological harvest of the twentieth century.

The Conditions

The changes brought about in the lives of men and women in the last hundred years have been greater and more rapid than during any other period in history, and these changes have been almost entirely due to the work of scientists and technologists all over the world. They have not only affected the way of living of all civilized peoples but have also vastly increased our knowledge about ourselves, the earth we live on and the universe around us. I cannot emphasize too much that the sum total of scientific knowledge and technological progress is an international achievement to which every civilized country has made some contribution.

Now before considering the contribution of the British Commonwealth, I should like to sketch what appears to a layman like myself to have been the main influences on the course of scientific and technical achievements since 1851 and their relation to one another.

The great stimulus of the 1851 Exhibition created a growing interest in technical education and research, followed by a widening of the scientific horizon which was soon to find expression in borderline subjects. For the next fifty years science advanced rapidly; but in most fields there was a wide gap between science and industry. Electricity was an exception, and the groundwork was already being laid for the electrical revolution of the Victorian age. Medicine was on the verge of breaking away from medieval practice and taking the first steps towards its modern pattern, while British colonial development stimulated the study of tropical disease.

Between 1851 and 1870, practice, in many industries, was ahead of science, and in that period the large number of inventions of the Industrial Revolution were progressively improved and widely applied. These inventions, which added so much to our industrial production, were mainly the work of British genius. They were of great economic advantage to this country and were quickly exploited commercially. New factories and plants were built to include the very latest ideas, and with the expansion of industry came the demand for more and more new ideas and greater efficiency. This demand was a direct stimulus to technological invention as well as an indirect stimulus to science. We are still struggling with the social results of this vast expansion.

From 1870 to 1890 the highwater mark of British industrial expansion, as compared with other countries, had been reached and the competition of the United States and Europe was just beginning to be felt. But the lack of serious competition hitherto had bred a feeling of over-confidence and satisfaction in the methods and processes employed. The result was a conservative attitude towards technical change and, particularly in the older industries, neglect of scientific research. Accumulation of wealth and the income from foreign investments in any event made the country as a whole less dependent on the efficiency of her industries. Concurrently a subtle change occurred in the type of British exports. So far the products of our machinery, such as rails and rolling stock, had been shipped abroad for immediate use; but now machines themselves were exported to do their work in the factories of Europe and America instead of in Britain. The result of this was to intensify foreign industrial competition between 1890 and 1914; but with the increasing demands from the Colonies the volume of British exports was not greatly affected.

Then came the critical years of the First World War, bringing a realization of the part science must play in the industrial and military strength of the nation. For the first time in history a real attempt was made to enlist the services of science in the war effort, and the Department of Scientific and Industrial Research was founded to further the application of science in industry through Government laboratories and through research associations.

The effects of these measures appeared clearly in the inter-war years, when there was a marked swing of education from classics towards science. Coupled with this, the War had directed the attention of many research scientists to practical objectives, so that after the War there was a rapid expansion of industrial research. Scientific progress was no longer confined to the work of a few brilliant individuals, but came also from teams of research scientists each working on different parts of the same problem. It was during this period that many new commercial research laboratories grew up, employing scientists to discover new processes and materials connected with their industry as a direct weapon of competition.

The War had also shown a great weakness in our dependence on foreign production for many vital articles, such as dyestuffs, scientific instruments and optical glass, in the manufacture of which scientific research played an essential part. This weakness was remedied with the help of the Key Industry Import duties, which gave the necessary support and encouragement to the establishment of these industries at home.

It is true that manufacturers in some of the older industries still clung to traditional methods in spite of the pressure of competition from America and other countries. In this connexion it is significant that the history of production engineering after 1890 is almost entirely confined to the United States.

It was, however, a period of rapid development in Britain. The invention of the internal combustion engine and the pneumatic tyre had opened new branches of industrial engineering, and the demand for fuel for motor-cars and aircraft gave birth to the new technology of oil. In the electrical, chemical and aircraft industries, science was fully enlisted in the fields of electronics, synthetic fibres, plastics, aerodynamics and light alloys. Consequently the outbreak of war in 1939 found us in a much stronger position

to meet the immense demands it made on all branches of technology for new gadgets, machines and weapons. From the outset science in all its forms and branches was harnessed and completely co-ordinated with the war effort. It was only the intimate partnership of science and engineering with the staffs of the Fighting Services that enabled us to meet swiftly and effectively the ever-changing menace of total war.

The tremendous demands on our industries had some good after-effects. Once again these demands revealed weaknesses where our industrial capacity was out of date. The realization of this has initiated comprehensive reconstruction on most modern lines. The almost complete absence of income from our foreign investments has forced us to rely once more on our capacity to make the goods the world requires. Our industry and productivity have shown a wonderful improvement; but there is still a lot more that can be done. The rate at which scientific knowledge is being applied in many industries is too small and too slow. Our physical resources have dwindled; but the intellectual capacity of our scientists and engineers is as great as ever, and it is upon their ingenuity that our future prosperity largely depends.

The Contribution

I would now like to make a brief survey of the British contribution to natural knowledge and technology and pay a tribute to some of the great men of science of the past hundred years.

In some branches almost the whole story can be told, since one problem after another has been solved by British scientists. In others there are many blanks and gaps where the vital links in the chain were forged abroad. But looking at the whole vast field of abstract and practical science there can be no doubt that during this period the contribution of the British Commonwealth has been of outstanding importance.

Our knowledge of the stars, the heavens, and our place in the universe has increased steadily through the centuries; but since 1851 some of the most important links were supplied by such men as Eddington, Jeans and Milne in their work on mass, luminosity and stellar evolution. Huggins made a great contribution with his application of spectrum analysis to astronomy, and Lockyer's discovery of helium in the sun had a significance far beyond the realms of astrophysics.

Coming nearer to the earth, the work of Abercromby and Shaw on the behaviour of the earth's atmosphere in the troposphere started the scientific study of weather and weather prediction, and Appleton's research into the ionosphere extended this to the upper air.

Chemistry has fascinated man from the earliest times, and vast progress has been made in the past hundred years both in knowledge and theory. Much fresh ground was broken by Crookes by his work on spectra, his discovery of thallium and of 'radiant matter' known later as cathode rays. Long after everyone was quite sure of the composition of the air, Rayleigh found another ingredient which he called argon and so started the hunt for other inert gases. In organic chemistry both Perkin and Robinson have added enormously to our knowledge of the structure of carbon compounds, and to our power to copy natural products synthetically. The development of X-ray analysis by the two Braggs, father and son, has given us a means of finding the actual arrangement of the atoms in the molecule and has revealed the accuracy of the chemists' conclusions about the architecture of molecules based on their reactions with one another. This is a most striking example of the power of the theoretical and practical scientist to penetrate Nature's secrets.

Going beyond the chemist and his molecules, we come to the physicist and the study of even smaller particles. Thomson's discovery of the nature of the electron was the first attack upon the integrity of the atom. Next, thanks to Rutherford's brilliant research and keen intuition, came the nuclear theory which revolutionized our ideas of matter. To prove it, he was the first man to succeed in the transmutation of an element. It is appropriate to mention Moseley's work on the X-ray spectra of the elements, as it already showed such great promise, before he was killed at Gallipoli.

Parallel with this activity in the physical sciences there occurred a technological revolution of even greater scope and variety. The Darbys of Coalbrookdale were the lineal ancestors of Bessemer, Thomas and Siemens, and the whole technology of metals. First, cheap cast iron followed by cheap steel, then steel from phosphatic ores, completely changed the materials available to engineers, shipbuilders and architects. Scientific metallurgy can be said to have started when Sorby first applied a microscope to the surface of metals. The way was opened for the investigation of the metallic alloys which came in quick succession from developments in which Hadfield and Rosenhain made outstanding contributions.

It was not long before the possibilities of these new materials were recognized, and the great majority of the mechanical developments of the period were due to new alloys which could withstand higher stresses. But before these materials could be fully used, Maudsley and Whitworth had to lay the foundations of production engineering, and Mushet had to do pioneer work in developing tungsten steel as the first high-speed cutting tool.

The reciprocating steam engine of the Industrial Revolution was the main source of power until Parsons invented the steam turbine, which revolutionized large-scale power production on land and sea. But that was not the only source of power to rival the push-and-pull engine. The internal combustion engine, in which Dugald Clerk and Akroyd Stuart were among the early pioneers, has proved to be a formidable challenger in many fields. In marine engineering, Froude's work on hull forms and propellers enabled the full benefit of the new prime movers to be reaped at sea.

Here I wish I could mention early British pioneers of motor-vehicles; but, as is well known, restrictive legislation drove the development of the motor-car abroad, until the repeal of the speed limit in 1903 gave scope to the genius of Royce, Lanchester and Ricardo. In place of the motor-car, however, we have Lawson to thank for the invention of the safety bicycle; and all wheeled vehicles except those running on rails owe their rapid development to Dunlop's invention of the pneumatic tyre. The material required for this started the vast natural and synthetic rubber industry, and has made famous the name of Wickham for a brilliant feat of smuggling, when he brought the rubber seeds from Brazil to Kew, from which sprang the rubber plantation industry of the East.

In flying, the names of the pioneers and their feats are legion, and more than in any other mechanical

science the development of aerodynamics has been shared by many nations; but Lanchester's vortex theory was one of the stepping stones to powered flight, and the achievement of Alcock and Brown in making the first Atlantic flight in 1919 speaks highly for the tremendous scientific and technological background of flying in Great Britain. Of outstanding importance and consequence was the genius which Mitchell brought to aircraft design, and, more recently, Whittle's pioneer work has given us the lead in jet engine production both for civil and military use.

Following on the immense progress in metallurgy and mechanical engineering, the most far-reaching development of the period has been that of electricity and electronics. Although the key discovery belongs to Faraday in an earlier period, the second founder of the science is undoubtedly Clerk Maxwell, with his classic treatise on electro-magnetism. The use of electricity for domestic and industrial purposes was helped by Wilde's development of the dynamo and then by Swan's incandescent lamps. Wheatstone and Kelvin pioneered the use of electricity for communication by their work on line and cable telegraphy. Wireless telegraphy soon followed, and the work on tuned circuits by Lodge, and Marconi's many brilliant developments made in Britain with the General Post Office and the Navy, soon made radio a practical proposition. Heaviside and Appleton made further contributions on the propagation of radio waves. It is interesting to see that the technique used by Appleton in his pulse-ranging on the ionosphere and upper layers was later developed by Watson-Watt into radar, which is now almost indispensable to airmen and seamen all over the world. Here Randall's development of the magnetron for high-frequency radar was one of the major contributions to the Allies' equipment for war.

Television has a wide parentage, but Baird's name will always be linked with the first successful pictures.

Another great innovation of this hundred years was the discovery and development of plastic and synthetic materials. The story starts with Parke's discovery of celluloid and Cross and Bevan's manufacture of viscose which gave birth to the rayon industry and the many later types of synthetic fibre. Perkin's mauve, first of the aniline dyes, and Kipping's new silicon compounds were, however, disregarded by industry in Great Britain. But we see to-day a change of heart in the development in our industrial laboratories of two new plastics, 'Perspex' and polythene, with almost an unlimited range of applications in the air, on the ground, and at sea.

The effect all this has had upon the citizen varies naturally with where and how he lives; but basically it has given him reliable light and heat in his home, push-button communication with almost any part of the world and home entertainment of a high quality. His transport on land, at sea, and in the air is quick, comfortable and clean. In addition, he has a vast range of materials with which to clothe himself and to furnish and embellish his home. Almost more important, these developments have brought about a complete change in his conditions of work.

But if the citizen has benefited, so too has science from the great array of new techniques that have been invented and the new tools with which the scientist and technologist can burrow, hack and worry at the growing mountain of problems to be solved.

So far I have dealt with the physical sciences. Now I would like to turn briefly to the biological and psychological sides, which after a slow beginning in Great Britain have made increasingly rapid progress.

The whole field of biological science in this period is overshadowed by the works of Darwin presented in his "Origin of Species" and "The Descent of Man". Nothing has done so much to widen man's thoughts as his conception of evolution as the great law controlling living things, "that progress comes from unceasing competition, through increasing selection and rejection".

In the basic study of living things some of the most important contributions from Britain were the pioneer work of Francis Galton and William Bateson in the field of heredity, Sherrington's work on the integrative action of the nervous system, and Dale's and Adrian's contributions to our knowledge of the transmission of nervous impulses.

The science of biochemistry is relatively new and Gowland Hopkins was its founder in Britain. His discovery of the significance of accessory food factors, leading up to the recognition of vitamins, started the modern science of nutrition. Other landmarks were Bayliss and Starling's recognition of the part played by hormones in the blood stream, followed by Banting and Best's isolation of insulin, and Harington's synthesis of thyroxin in Edinburgh.

Fleming, working on mould cultures, discovered the antibacterial properties of penicillin, and later Florey and Chain, at Oxford, found that penicillin could be extracted in a highly purified form, and used it to treat human disease.

Modern surgery can be said to have been born in Scotland with Simpson's discovery of the use of chloroform as an anæsthetic and Lister's antiseptic technique based on Pasteur's bacteriological discoveries. A further advance of the greatest value to surgery as a science was Macewen's aseptic technique, which made surgery clean and safe, followed by his classic work on the brain and spinal cord.

If Lister was the father of modern surgery, then Manson was the father of tropical medicine, and it is particularly in this field that the British contribution has led the world. The discovery by Ross that malaria is carried by the anopheles mosquito and, much later, the work of Fairley in Australia on its prevention and cure, have been of the greatest benefit to mankind. Bruce will always be remembered for his discovery of the part played by the deadly tsetse fly in the transmission of sleeping sickness and his work on Malta fever. Finlay, Adrian Stokes and Hindle stand high among the names linked with the study and prevention of yellow fever.

These were all vital efforts towards the prevention of sickness; but there is another aspect of medical practice in which the Commonwealth has taken a leading part—the promotion of health. It was Sir John Simon, the first medical officer appointed to a central authority, who made a careful statistical study of the causes of sickness, with the view of taking effective measures for the health of the community at large. Through his leadership, health services have been provided in regular stages throughout the country. At first these were largely aimed at providing pure water, effective sanitation, and the abolition of slums; but since the beginning of the present century the *personal* health services, especially in the case of mothers, babies, and school children, have become national in scope and lead the world.

There are two other fields in which the biological sciences play a major part. The first is in the preservation of food and in nutrition, which has had the most profound economic and social effects. The ability through freezing, drying and canning to import large quantities of food has enabled a rapidly increasing population to maintain and increase its standards of living, which would have been impossible had it been dependent on British agriculture alone. The scientific study of nutrition has made it possible to improve the health of the population and in war to feed the people with the minimum of waste.

Mort had the first freezing works in the world at Sydney, and was a pioneer in refrigeration; but success in transporting meat to Britain had to wait for the development of more reliable refrigerating plant. Since 1918 the Food Investigation Laboratories of the Department of Scientific and Industrial Research, of which Sir William Hardy was the first director, have established the basic biological knowledge on which the storage and transport of meat, fish and fruit are now largely based.

The second field is in agriculture, where in order to compete with cheap foreign foods the most successful farmer is one who enlists the full assistance of science. Lawes, who discovered how to make and use superphosphate, and started the great fertilizer industry, was quick to realize this. He founded Rothamsted, now the oldest agricultural research station in the world, and there he and Gilbert carried out the first scientifically controlled field experiments which laid the foundation of agricultural science. Later, Biffen's pioneer work in plant breeding at Cambridge became one of the greatest contributions to the problem of feeding the world's growing population. He showed how it was possible to breed strains of wheat combining resistance to disease with high yields and good milling properties. In the field of animal breeding, the foundation of the most important aspect of British agriculture to-day, I will mention among the many investigators only Cossar Ewart and Crew, who did so much to advance its scientific study here in Edinburgh. The mechanization which was to revolutionize farming in all parts of the world was also under way and Britain was playing a leading part. The reaping machine, for example, was invented by Patrick Bell in 1826 although it was not manufactured until 1853.

There is no need to point out the effect which all these improvements, discoveries and inventions have had on society. It is this group of biological sciences which have had the most far-reaching social results, and it is particularly during and since the Second World War that it has been possible to exploit them.

There is one science which I have not yet mentioned. It is both the youngest science and the oldest problem. The study of man's mind was the province of the philosopher until the middle of the nineteenth century, when it separated from him and began its independent existence as the science of psychology. The foundations were not laid in Great Britain; but important contributions were made, both from the biological and the philosophical sides, by men like Ferrier, Bain and Ward. Sully's work on child psychology was the first of its kind. But probably the most outstanding figure in this country was Galton, whose teaching is widely respected in all psychological laboratories, and who was the first to develop an interest in the mental differences between individuals—a field in which British psychology has made some of its greatest contributions. Again, it is only recently that full practical advantage is being taken of the progress made in this branch of science; but the results of that application may be as important as the many more easily understood developments in the purely physical world.

The Implications

The story of the British contribution to science in the past century is indeed impressive, and I am very pleased to have this opportunity of paying tribute to the men whose achievements I have been discussing. But this story would not be complete without studying the wider implications of their work and examining some of the lessons to be learnt from it.

The concrete measurement and indirect effect of all scientific effort is the general improvement in the conditions in which people live and work; it is in the improvement in health, in the expectation of life and standards of living; the latter including not only food and clothing, but also housing, home comforts, medical care, education, books and newspapers, recreations and travel facilities. In every one of these directions the progress that has been made has amounted to a revolution.

Not all this springs directly from science and invention. Much has been due to the politicians and administrators, and behind them to religion, morals, education, art and the complex influences which we call culture. But even there science has stood beside the authors of progress to advise, to help and sometimes to guide.

Now as science and technology are so vital to the future strength and prosperity of the British Commonwealth, the great problem is to discover the conditions under which they are most likely to flourish. The records show that both depend very much on co-operation, and upon the linking up of a long chain of discoveries, one with another; so that it is quite exceptional for the credit of a great advance to belong to one man or even to one country, although it will always require the flash of inspiration to weld the links into the chain. To-day the development of team-work in laboratories has made this truer than ever. For many reasons, but principally because of the increasing complexity of research and its cost, such team-work is becoming more and more the rule. We need not repine at this; but it would be a disaster if the individual inquirer working in his own laboratory were discouraged out of existence.

While the quality of scientific work is determined by the quality of the scientist, the quantity of scientific output is determined by the money available. The rapid progress of science in Britain has owed much to the growing support and sympathy of government and individual benefactors and to the endowment of research by industrial corporations. However, the basic discoveries that mark the great advances depend on the accident of individual genius and are not at our command.

The scope and intensity of the progress of applied science and technology, on the other hand, bear a close relationship to the circumstances of the time. Technology, as the combination of scientific knowledge with the practical ability of the inventor to apply that knowledge to the solution of particular problems, comes into play with any new discovery of scientific fact. The latest particle of truth is then developed, according to the circumstances of the time, for military, commercial or medico-social purposes. It is a sad reflexion that the urgent demands

of modern war can produce advances that might otherwise take many years to develop, especially in the costly and uncertain experimental stages.

The rivalry between large commercial undertakings, using science to improve their products or processes as a direct means of competition, has produced a steady flow of improvements and developments. However, the fruits of this form of scientific work are sometimes open to considerable misuse. The discoveries of these commercial laboratories may be kept secret, and in some cases a number of teams may be working on the same problem, which may have already been solved elsewhere. The buying up and suppression of patents and discoveries to protect equipment from becoming obsolete has also been known to happen. I am glad to see, however, a change of outlook in the growing quantity of publication of the results of industrial research.

It would seem that science has become so well established that nothing can stand in the way of its natural growth. This is far from the truth. Since the earliest times the natural conservatism of laymen has acted as a powerful brake to the adoption of new ideas which do not rigidly conform to his notion of the correct order of things. In its most violent form it will produce unreasoning anger, utter disbelief in face of the clearest evidence or provoke plain ordinary laughter. The storm raised by Darwin's "Origin of Species" is an excellent example where even scientists failed to keep an open mind.

The position seems better to-day, and I am sure that Sir Harold Hartley, our immediate past president, spoke for all scientists when he said: "To-day, with our greater understanding, there is humility in the minds of all scientists. The further we penetrate into Nature's secrets the more clearly we see the ever-receding frontiers of knowledge."

The resistance towards anything new or unexpected is balanced, on the other hand, by bursts of enthusiasm that some particular discovery or invention will see the end of all our troubles. The belief in the philosopher's stone seems to be just as great as ever.

As the front of pure science has advanced, so its lines of communication to practical exploitation have got longer and longer. The time was when the whole process of discovery, application and exploitation could be achieved by one man. In our time a great army of scientists, technicians, inventors, designers and production engineers is required to keep the lines of communication open. Quite how important some of the members of this follow-up team have become is not always appreciated. In his presidential address in 1948 Sir Henry Tizard emphasized this point when he said: "All depends on good design and production. Our weakness in the war was not to be found in what was best to do, nor in the scientific work of how to do it. It was when the stage of design and production was reached that we fell short of the best standards."

This was true already when Whitworth invented the screw micrometer, which was afterwards put into production in Germany and the United States, and up to the First World War all micrometers had to be imported into Britain.

To Prof. Kipping of Nottingham goes the credit for the basic work which led to the development of silicones in Russia and the United States, and yet until this year we have been dependent on imports from the latter of marketable silicone products.

There are many cases in the Navy where a piece of apparatus has been used operationally exactly as the inventor put it together, with all the resulting disadvantages in maintenance and efficient operation. The limitation in performance, except in some cases, is practical as opposed to scientific. Where the basic scientific principles are known by all nations the advantage lies in the good design of equipment for practical use.

A more general and far-reaching matter for concern, and possibly the most vital factor affecting the industrial application of scientific research, is the lack of a co-ordinated system of scientific and technological education in Britain. Excellent as they are, the existing institutions, which have grown up to meet particular circumstances, do not produce anything like enough trained technologists to meet the urgent needs of scientific development in industry and to provide leaders for the future. It is to be hoped that the new and rather uncertain science of education will develop sufficiently quickly to point the way to a speedy solution of this problem.

The shortage in Britain of "personnel trained and eager to apply scientific knowledge and scientific methods to practical ends"—as Sir Ewart Smith said last year—is only one of the many shortages which the world is now facing. Among them are food, nonferrous metals, steel alloy metals and sulphur. These very shortages are due to the scientific complexity of present day life, and it is only by science that they can be overcome. Naturally, there are many ways of tackling this problem; but the most obvious are: first, by improved design to secure economy in production and the minimum use of scarce materials; secondly, by the development of substitutes made from raw materials which are still abundant; thirdly, by the reclamation of scrap and improved methods of using low grade ores; finally, the development of renewable raw materials such as timber to satisfy the world demand for cellulose. Some of these shortages are partly due to the huge inevitable waste of war and its consequences, and partly to the lack of any comprehensive survey of the world's resources and requirements. It is only by an accurate knowledge of the world's resources that we can foresee the scope and magnitude of the future problems which science and technology have to meet and which only they can solve.

It is, therefore, good news that the Economic and Social Council of the United Nations has resolved "to promote the systematic survey and inventory" of those resources which are not already covered by the Food and Agriculture Organization.

We have evolved a civilization based on the material benefits which science and technology can provide. The present shortages are a timely reminder of the slender material foundation on which our civilization rests, and of our dependence upon science and technology.

The Conclusion

The pursuit of truth in itself cannot produce anything evil. It is in the later stage when the facts dug up enter the process of application that the choice between the beneficent and destructive development has to be made. It is quite certain that it is an exception if any particular discovery cannot be used equally well for good and evil purposes. Happily the beneficent exploitation of scientific knowledge has kept pace with its destructive application.

In a mid century article *The Times* put it this way: ". . . It has been an age of great achievement. The lines of progress in which the Victorians trusted

have been pursued farther and faster than they foresaw. Scientific discovery, from which above all their doctrines of progress derived, has swept forward on an enormous front. The conquest of the air has made possible an intercourse and understanding between distant peoples such as our ancestors could not imagine—and it has been diverted to the vast destruction of men and cities. The invention of wireless telephony has opened a channel through which liberating truths might be proclaimed to all the listening earth—and every would-be despot has used it to suborn the blind masses into the worship of false gods. The medical art has performed miracles; the cures of immemorial pestilences have been found, infancy has been safeguarded and old age tended, so that the normal expectation of life has been extended by years—aside from the new and universal apprehension of sudden death."

To my mind it is vital that the two sides of scientific development are fully and clearly understood, not only by the research scientist, inventor, designer and the whole scientific team, but also by all laymen. The instrument of scientific knowledge in our hands is growing more powerful every day; indeed, it has reached a point when we can either set the world free from drudgery, fear, hunger and pestilence or obliterate life itself.

Progress in almost every form of human activity depends upon the continued efforts of scientists. The nation's wealth and prosperity are governed by the rapid application of science to its industries and commerce. The nation's workers depend upon science for the maintenance and improvement in their standards of health, housing and food. Finally, superiority or even our ability to survive in war is a direct measure of the excellence and capacity of the scientific team.

This team of research workers and engineers has a dual responsibility, one for its work and the other as informed citizens, and it can only fulfil its proper functions if its members have a sound general education as well as a thorough training in science. It is no less important that the people who control the scientific machine, both laymen and scientists, should have a proper understanding and appreciation of what science has grown into and its place among the great forces of the world.

It is clearly our duty as citizens to see that science is used for the benefit of mankind. For, of what use is science if man does not survive?

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

A HUNDRED YEARS OF METEOROLOGY

IN his presidential address to Section A (Mathematics and Physics), Sir David Brunt outlines the development of meteorology during the past hundred years. Before dealing with his main theme, he points out that the Greek philosophers Aristotle and Theophrastus had developed meteorology in the fourth century B.C. so far that their ideas dominated the meteorological thought of Europe for nearly two thousand years, while Pindar set up a standard of forecasting which even to-day is difficult of attainment, except on rare occasions.

The re-awakening of independent thought took place about the time of the foundation of the Royal Society in 1660, and the influence of that Society remained very great up to the time when control of official meteorology in Great Britain passed into the hands of the Air Ministry in 1920.

Many workers with creative minds have, of course, been indispensable on the research side of meteorology, and the names which Sir David mentions include those of astronomers such as Halley and Laplace, and physicists such as Lavoisier, Wheatstone and Glazebrook. Of particular importance was Sir Napier Shaw, the more so because Shaw was instrumental in adding the names of those most prominent in Great Britain during the past sixty years, for example, W. H. Dines, C. J. P. Cave, E. Gold and G. I. Taylor. Shaw's services should be judged against the background of the Meteorological Office, to which he went as director in 1905. Shaw found a 'Slough of Despond', into which he contrived to instil some of his own enthusiasm. Shaw made the greatest written contribution to meteorology of the century when he published, in 1906, the memoir entitled "The Life History of Surface Air Currents", a work in which he was assisted by R. G. K. Lempfert. This anticipated the paper entitled "Life Cycle of Cyclones and the Polar Front Theory of Atmospheric Circulation", by J. Bjerknes and H. Solberg, which has laid the foundations of the method of forecasting weather which has been developed during and since the Second World War.

Turning then to the research work now being done in Great Britain as part of a revived scheme of international co-operation, Sir David points out that the problems receiving increased attention include: (*a*) the nature of the depression of middle latitudes; (*b*) effects of atmospheric radiation and absorption on the heat balance of the atmosphere; and (*c*) formation of cloud, rain, ice-crystals and snow. Items (*b*) and (*c*) have given the most positive results; as regards (*a*) we cannot predict where the next depression will form, or even explain the precise conditions which led to the formation of yesterday's depression. In the case of (*b*) the approximate balance of radiation and absorption in the atmosphere can now be evaluated by graphical methods due to Elsasser in the United States and Robinson in Britain. In the case of (*c*) we now nearly understand the condensation of ice, and also the artificial production of precipitation. Another new matter which is being investigated has come to the fore as a result of further advances in aircraft design, making flights possible at very high altitudes. These have revealed a new phenomenon called the 'jet stream'. This is a stream of air, at levels between 15,000 ft. and 40,000 ft., moving roughly eastwards at speeds of 130 knots or more, and traceable for great distances downwind, but sharply restricted vertically and transversely.

CHEMISTRY AT THE MID-CENTURY

IN his presidential address to Section B (Chemistry), Sir Cyril Hinshelwood points out that a century ago there was a great wave of intellectual optimism, more recently succeeded by disillusion and pessimism from which recovery is to-day far from complete. At this moment there may be profit in taking stock of the realities of the situation and in examining against the general background some particular themes of interest to the science of chemistry.

The great chemical events of the past century have been the evolution of views about the basic substratum of things, the perfection of the arts of synthetic chemistry, and the growth of knowledge about the laws of energy and of the intimate mechanism of chemical changes. Now after a long and eventful approach the chemist stands face to face with the problem of life itself.

Early ideas about atoms and the manner of their union were naive. They have gradually become more sophisticated and more abstract, and now chemical valency must be interpreted in terms of electrons with properties quite unlike anything known to ordinary observation. Behind this there seems to lie some deep mystery relating the possibility of detection with the very existence of the entities postulated in physical theories, and in a glass darkly one seems to see here some connexion with the mind–matter problem itself. The present situation is unsatisfying to many; but it should not be concluded too readily that the limit of knowledge, or taking long views, even of the power of human understanding is yet reached.

Much of chemistry is of a more workaday character and unconcerned with these deep questions. Structural chemistry, now in the early stages of becoming a mathematical science, has not only revealed the underlying atomic patterns of things but also enabled the chemist to weave designs of his own choosing. The deeper understanding of mechanisms has not only led to understanding but also to control.

It has often been questioned whether the powers of chemistry are used for good or evil ends. To this an emphatic answer may be given: chemistry has, in fact, conferred vastly more benefit than harm on mankind; and men of science are in no way responsible for the abuse of their discoveries by others. The desire to inhibit scientific discovery rests, moreover, upon an utter lack of faith in human destiny.

The detailed understanding of what happens in chemical changes has revealed a picture surpassing in wonder that conceived by the poetic imagination of Lucretius. It is now being extended to the events occurring in living cells. The selective influencing of cell processes opens the door to the great field of chemotherapy, though generations may pass before all the promise of this is fulfilled.

As the cell discloses its secrets there will emerge the possibility of deep-seated intervention of man into the fashioning of his own biological future, and those of little faith may raise more vigorous cries than ever.

Men of science at the mid-century are faced with difficult problems, both scientific and human. If in face of hopes and fears they seek a policy, they will do well simply to follow the advice of Candide: "Il faut cultiver son jardin". If they do this unconcernedly, their own garden will not fail to go on producing its fruits.

GEOLOGY AND MILITARY STRATEGY

THE relation between geology and the movements of armies forms the theme of the presidential address to Section C (Geology) by Prof. W. B. R. King. Military operations in north-west Europe during the past two hundred and fifty years have illustrated as well as in any part of the world that the ability of a commander to move, feed and supply a large army at will is one of the prime necessities of a campaign, for this leads up to the successful deployment for the actual battle. The first of these necessities clearly depends on the general topographical lay-out of the country viewed in a broad way, while the details of the battle are often influenced by local geological controls.

Belgium, between the Meuse-Sambre and the rivers draining towards the Scheldt, has often been a 'corridor of invasion' between east and west, and many of the great battles from the time of Marlborough onwards have been for the control of this 'corridor'. The early battles of 1914 and 1940 were clearly influenced by the presence of this natural east–west throughway. The line taken up by the Allies in May 1940, based on the Scheldt estuary–River Dyle–Meuse valley above Namur, left only a short stretch of line without a natural defensive river position. That the Germans were able to turn this line by advancing through the difficult Ardennes country does not say that the line chosen was not a good one. Other defensive lines in northern France are essentially river lines, like that of the Somme running across what is, on the whole, open country.

When the general geological pattern of north-west Europe is considered, it is clear that the oft-repeated pattern of military operations can be co-ordinated with the physical geography of the area and this is clearly controlled by its geological history.

North-west Europe can be divided into five main areas: (1) the low-lying area of the north with wide sluggish rivers and large areas actually below sea-level; (2) the Chalk and high-standing Tertiary areas of Belgium and northern France with relatively few natural barriers; (3) the Palæozoic and igneous rocks of the Ardennes and surrounding Bunter Sandstone outcrops, a wooded area of high relief with deeply incised valleys; (4) the Paris Basin consisting of an outer zone of marked dip and scarp topography, a middle zone, that of the Chalk, an area of open country of well-drained flat surfaces and an inner zone of dissected wooded hills; (5) the Palæozoic area of Brittany and west Normandy with its strong east–west 'grain'.

Clearly, of these divisions, (2) and the centre zone of (4) are those most suited to easy movement of large armies, and historically it is in these areas that the main military operations have taken place. But besides the controls due to the solid geology, the area as a whole was in the periglacial zone during the Pleistocene Ice Age. This has had great influence on the physical features. The effect of a lowered sea-level due to abstraction of oceanic waters to form the ice-caps has been to cause a temporary rejuvenation of all the valley systems, particularly in their seaward portions. These overdeepened valleys were drowned on the recovery of sea-level to near its former position. This resulted in either large estuaries or, as occurred in most cases, valleys filled with recent unconsolidated sediments including peats.

It is these deposits which make so many of the river lines such strong defensive positions, for the

whole valley floor, not merely the river, is the barrier. The other important result of the periglacial climate is that it leads to the formation of vast sheets of loess spread over the country as a blanket. On the slopes this has been largely removed, but on the plateau areas it still exists. Its effects are numerous. On the loess soil the type of agriculture is plough lands with large open fields without hedges. The silty nature of the soil renders it firm and quick-drying during summer but highly treacherous in winter and spring. It is on such plateau lands during the summer months that airstrips for servicing fighter aircraft could be prepared with least work and where the open country was particularly well suited for rapidly moving armies.

The effects in the coastal regions of movements of the strand line were important. Along all the Channel coasts it was known that peats and clays of the 'Submerged Forest' existed in patches. The location of patches of these under the sands of the Normandy beaches necessitated extremely intensive study, for unless covered by a sufficient thickness of sand, vehicles were liable to become bogged. The work done by Prof. F. W. Shotton and others on this problem was well justified by the results.

It is seen, therefore, that the solid geology of the area controls the broader problems of strategy, while the features resulting from the periglacial position during the Ice Age has had two effects which have been of the greatest importance in controlling details. These are the infilling of the overdeepened valleys with unconsolidated alluvium, rendering them effective barriers, and the presence of the loess-covered plateaux which form large areas suitable for 'open' warfare and give rise to numerous tracts which can be turned rapidly into temporary airstrips for the landing and servicing of fighter aircraft, a feature of the greatest importance for modern armies.

ORGANIC DESIGN

IN his presidential address to Section D (Zoology), Dr. C. F. A. Pantin remarks that by the beginning of the nineteenth century two principles had emerged from the study of comparative anatomy: first, that structures are adapted to the function which they serve; secondly, that some plan underlies the architecture of whole groups of animals. Purposive adaptation was used as an argument for Divine design. So also was the existence of an underlying anatomical plan. This plan showed two features. First, animals exhibited grades of organization which we term 'higher' and 'lower'. This was partly the old anthropomorphic over-simplification that placed man at the head of a *Scala Naturæ*. The error still persists because it contains an element of truth. 'Higher' animals show functional differentiation which leads to increased independence of the environment. The price of this independence is centralized control, particularly by a brain.

The second feature is that animal organization is found to be based on one or other of a series of architectural types, such as the vertebrate, the molluscan and so on. One hundred years ago, Richard Owen gave precise definition to this idea in his conception of the archetype, which he considered as the expression of an underlying abstract plan—in much the same way as to-day we may consider the groups of the elements of the Periodic Table give expression to such a plan.

The "Origin of Species" gave a totally new interpretation of these things. The type and its structural homologies were consequences of evolution from a common ancestor. Purposive adaptation was the negative image of natural selection.

By 1918 abstract comparative anatomy, even in evolutionary guise, had lost much of its power to inspire research. Many new lines of work opened, particularly in the physiology of animals and their tissues. Almost all these lines have led back to morphology, though from a very different point of view from that of the older comparative anatomists. New relationships emerged at the molecular level of structure. Biochemical similarities appeared between organisms which were utterly sundered in their evolution, as in the carbohydrate metabolism of fermenting yeast and of contracting muscle in vertebrates. Such similarities arise independently because the materials available for the construction of organisms are of few kinds and of unique properties. Consequently the same materials, and these alone, are available again and again for the construction of functional systems independently in different sorts of organism.

Once these limitations are introduced at the molecular level, they affect all higher levels of structure. One of the most remarkable features of comparative physiology is the repeated and independent utilization of the same kind of machinery for muscular movement in quite different animals.

As in the structures erected by engineers, so in the organism, there are three factors governing design: first, any functional problem can only be solved in a limited number of ways; secondly, for any solution only materials of limited kinds and properties are available; thirdly, the engineer selects a solution which he can execute with the materials available. In the same way we may say of living organisms that natural selection gives reality to one or other of a series of possible structural solutions limited by the properties of matter and energy.

As a result of these limitations, we repeatedly find the same structural solution of a functional problem achieved by quite unrelated organisms. The most striking example of this is the independent development of similar nervous machines by which organisms execute their behaviour.

THE CENTENARY OF SECTION E (GEOGRAPHY)

THE year 1951 marks the centenary of Section E (Geography) in the British Association, and its president, Dr. O. J. R. Howarth, surveys its history and achievements. The subject was previously subordinated to geology, and for some years was confined to physical geography. The establishment of the new section, in which ethnography was at first included, was due to Sir Roderick Murchison. He helped to found the British Association and also the Royal Geographical Society: he was to become a general secretary and afterwards president of the Association, and he maintained an intimate interest in the new Section, assuming its annual presidency no less than seven times. His first conception of its main function was that it should deal with travel, and should attract the interest of lay members of the Association by bringing before them

eminent explorers in person: "A noble procession of explorers passed across the stage of the Section"—Burton and Speke, Livingstone and Stanley, Wallace, Sturt, Palgrave, Scoresby, Ommaney, and many more.

The standing of geography as a true science was viewed with doubt by scientific purists. As a result, geographers and others disputed the question 'What is geography?' at greater length than was justified. The Section never actually debated this question; but a succession of addresses and papers attempted to answer it in various terms: those who in the earlier years of the Section saw the answer most clearly were Strachey and Clements Markham. The present address tries to show that "what Geography has achieved in the century we are reviewing, and what Section E has very effectively aided in achieving, is to demonstrate an outlook wider in horizon than those of the other departments of science with which it is associated, and to help to bring them into a harmonious focus".

By means of examples from the sectional transactions, the developments in British geography in various directions are traced—survey and cartography, geomorphology and the introduction of natural regions by Herbertson, human geography, and geography as an educational subject. Occasion is taken to refer to the work of many of the leaders in the development of geography—Keltie, Mackinder, Mill, Chisholm, Dickson, Geddes, Roxby and others. Dr. Howarth had personal contacts with some of these; but has not ventured into the fields of the work of those who have come after them and still are active. He suggests, however, "that in the century which is past British geographers have enunciated their principles and begun to apply them; have indeed applied them so far that the time is ripe to express them, not only in terms of individual researches (as is done) but in terms of a new geographical encyclopædia"—a suggestion easy to make, but less easily carried out "against the barrier of present-day costs".

Following upon the remarks on geography in education, it is suggested that to foster the instinct for admiring and preserving natural beauty is a function of geographical teaching alongside the organizations and individual activities which work to that end. "In this connexion we owe constant attention to the literary side of our subject, for much can be achieved by well chosen words, whether with or without opportunity for visual guidance." Geographical works are not the only sources of inspiration: by way of example, an illustration is quoted from the work of Robert Louis Stevenson.

There is an appendix to the printed version of the address, in which very brief biographical notes are provided of some seventy geographers and supporters of geography mentioned in the text.

NATURE OF PROFIT

To the questions what profit is and by what causes it is shaped and determined, economic science has not yet supplied answers which command general agreement. In his presidential address to Section F (Economics), Prof. R. G. Hawtrey points out that the classical economists, Adam Smith, Ricardo and Mill, recognized that profit must be distinguished from interest. Profit is the remuneration of the active head of an enterprise, whereas interest is paid, for the use of money, to a capitalist who takes no active part. The profit remaining after providing for interest is, therefore, remuneration for services rendered. But it differs from a wage or salary in that it is proportional to the magnitude of the trader's business, so that an expansion of the business may mean an indefinite multiplication of his income.

Marx accepted the classical view of profit and went so far as to describe the profit-making capitalist as a 'wage labourer', but with the qualification that the wages which he claims "do not depend on the degree of his exertions".

Marshall's treatment of profit had an apologetic flavour. He approached the subject from the point of view of a representative firm, one not exceptional either in efficiency, size or luck. The profit of such a firm would not be more than fair remuneration for services rendered. The rate of profit would vary widely. But an essential part of the cost of using capital is risk of loss, and uncertainty means inequality. However, it was the concentration of industry in big units that Marx had attacked, and Marshall's representative firm did not pretend to offer a defence against that attack.

Marx had in mind the concentration of industry that mechanization makes possible. But there had been from time immemorial another kind of concentration, that of the large-scale merchant's business.

The purpose of production is to meet needs, and the function of the merchant is to marry the product to the needs which it is to meet. It is a skilled service remunerated by the difference between buying price and selling price—in fact, by profit; and the merchant's income has the special characteristic of profit, that it can be multiplied in proportion to his transactions. The merchant's profit is the remuneration of selling power. It is paid for his skill in selecting goods to suit the needs of consumers and users. The industrialist is no less a seller than the merchant, and his profit is likewise the remuneration of selling power. He has also other responsibilities, but can delegate them to a salaried staff. The responsibility for selling attaches inseparably to the *owner* of the product to be sold.

How then are profits determined under competitive conditions? The profit margin in any trade must be such as to secure a reasonable income to a newcomer. It will be regulated by the *magnitude* of the business that the newcomer with his command of capital and business connexion can expect. Even the passive shareholder, being part-owner of the product to be sold, gets more than bare interest on his money. That is his reward for making a wise selection among profit-makers to whom to tie his fortune.

Concentration of selling-power is more productive of near monopolies than concentration of industry, but is not always so serious an abuse as appears. The big concern can afford to be content with a narrower profit margin than the small; and the accusation is usually not that its prices are extortionate, but that it treats its competitors harshly.

Profit-making is attacked nowadays from within the capitalist system. The advance of democracy has given an equalitarian bias to taxation. Here the danger is a destruction of saving at its most fruitful source.

2,000 YEARS OF ENGINEERING

SIR CLAUDE GIBB's presidential address to Section G (Engineering) traces the development of engineering from prehistoric times up to the present day and concludes with a prediction of future developments.

Engineering was born of the requirements of man, who, during his gradual development from a barbaric savage, fashioned tools and weapons to obtain food and to protect himself from the beasts of the forests. With the growth of civilization, man required irrigation schemes, canals, docks and harbours, good roads, palaces and temples, and the engineer had to use much ingenuity to provide these wants.

Ancient Greece furnished us with a number of eminent engineers, including Alexandrinus, Hero of Alexandria and Archimedes, and their work formed the basis for our knowledge of many subjects. The Romans also did much to further the art of engineering, the building of roads being one of their greatest achievements.

As the mining industry in Great Britain developed, some form of pumping engine and raising gear became necessary. Engineers turned their attention to this problem, which resulted in the introduction of the reciprocating engine. Engines of this type were also used for driving the paddle-wheels of sea-going vessels, and this eventually led to the introduction of screw propulsion, and the general use of steam engines at sea.

Some cheap and quick method of transporting coal from inland collieries to the river shipping points led to the construction of steam locomotives for coal haulage, and later the steam locomotive was adapted to passenger-train service.

Tribute is paid to the work of the engineers and physicists who gave us the laws of thermodynamics. Watt, Count Rumford, Carnot, Joule, Sir William Thomson, Rankine and Clausius all played their part, and it was the work of these physicists that made possible the rapid advances in steam engineering.

Due to the activities of many inventors, the beginning of the nineteenth century was an important period in the history of electricity. Electric generators came into being, and the electric telegraph services were introduced. Later the trans-Atlantic telegraph services, the telephone and electric lighting all made their appearance. Sir Joseph Wilson Swan and T. A. Edison gave us the incandescent electric light; then came the public lighting companies, followed by Ferranti and his work at the Deptford Power Station.

Equally important developments took place in the prime movers for driving the electric generators. Starting with the semi-portable agricultural type of engine, the Peter Brotherhood high-speed direct-coupled engine was introduced, followed by the Parsons epicycloidal engine, the Willans engine, the Bellis engine and finally, in 1884, the Parsons turbine. After the success of the turbine for the driving of electric generators, Parsons attacked the problem of adapting the turbine to marine propulsion and, after many initial disappointments, was equally successful. It was Sir Charles Parsons's work which made possible the large turbo-alternators used in central power stations and the large liners, cargo vessels and naval ships of to-day.

The advent of coal gas at the beginning of the nineteenth century saw the introduction of the gas engine and its development by Otto and Clerk. While these developments were taking place, the discovery of petroleum led to the use of oil instead of gas as fuel, the earliest oil engine to achieve success being the Priestman engine introduced in 1885. The Daimler engine followed; this was the beginning of the modern petrol engine, and its dramatic use for nearly all modern self-propelled vehicles.

The success of the petrol engine on land was followed by its use in the air. During the First World War, rapid advances were made in the design of aeroplanes, and in 1919 the Atlantic was crossed by aeroplane. Research work undertaken by Sir Frank Whittle gave us the jet-propelled aeroplane, and the development work during the Second World War produced the large aircraft used for the present-day long-distance passenger services.

Although efforts had been made at the beginning of the century to introduce gas turbines, it was not until about 1935 that serious attention was again given to the subject. While the War slowed up these developments, work still proceeded. On the Continent, gas turbines for outputs up to 27,000 kW. are in operation and in Great Britain machines of 10,000 kW. and 15,000 kW. are nearing completion.

In recent years considerable attention has been given to the work of the scientific men investigating nuclear energy, and to the possibilities of adapting this source of energy to commercial work. The first atomic pile was put into operation in the United States in 1942, and during the War considerable progress was made. Since 1945 atomic energy establishments have been put into operation in Great Britain at Harwell and at Sellafield.

In predicting the developments of the future, Sir Claude considers large-scale railway electrification is possible, following the production of electrical energy from the use of fissile material. To justify the high initial cost of an atomic energy plant, the production of electrical energy by fission must be carried out on a large scale, and so electrification of railways using electrical energy on a large scale will automatically result. He considers the jet or gas turbine cum jet will be used to the exclusion of all other means of propulsion for all types of aircraft. This type of prime mover meets the requirements so admirably that it is difficult to see how any other form of prime mover can compete. On land, the gas turbine will be used possibly to supplant the Diesel engine; but for very large powers the steam turbine will still be used. He sees no difficulty in making gas turbine units of 100 h.p. which could be fitted to motor-cars within the space now occupied by petrol or Diesel engines, the only problems requiring solution being a low cost and highly efficient regenerative heat exchanger.

Large-scale use of electricity for pump-produced rain and for soil heating will help to solve our ever-growing food shortages, and supersonic frequency electronically produced vibrations will become an everyday thing in our industrial, domestic and medical life.

EARLY CELTIC METAL-WORK IN BRITAIN

THE presidential address to Section H (Anthropology), by Sir Cyril Fox, opens with a reference to the great collection of Celtic metal-work from Llyn Cerrig, in Anglesey, of the period 150 B.C.–A.D. 50, spread out on a workroom bench in a museum in war-time. For a study of parallels to

individual pieces, museum collections were not then available; Sir Cyril was dependent on the literature, and found it very inadequate. That sense of inadequacy was the reason for choosing the subject for his address.

The character of this Celtic metal-work is discussed, specially fine examples referred to, and the absence of good monographs deplored. Some large hoards discovered fifty to a hundred years ago, it is pointed out, are not yet completely published or assessed. Reasons for the lack of enterprise thus indicated are suggested, and remedies for the lack of interest in this first flowering of British art outlined.

After referring to Dr. Jacobsthal's important researches, which promise, in time, a comprehensive survey, Sir Cyril outlines his own investigations: in brief, he has been concerned with the life-history of a particular artistic idea—or the art-history of a particular motif or group of motifs—in the last hundred and fifty years of Celtic freedom in southern Britain. The antecedents of the Llyn Cerrig plaque, the piece first chosen for investigation, its development as a three-dimensional work and transformation into a two-dimensional pattern, and the variations that flowed from it, are aspects that find a place in the series of published papers on the subject.

None of the more elaborate of the British Celtic patterns had hitherto been intensively studied; it is now seen that some at least are not so individual as to be at this distance of time inexplicable, but form closely related groups which can be placed in evolutionary series. The dependence of the Celtic craftsman on traditional patterns and the slow *tempo* of change despite his originality of mind and advanced technique are factors which make such elucidations possible. The backs of many Celtic mirrors, for example, are decorated, and this decoration is regarded as springing from one source, namely, the triskele, present on the Llyn Cerrig plaque. It culminates in the well-recognized high achievement of the Desborough mirror, wherein the graceful design of the mirror-back is matched by the beauty of form of the handle, both being fused, by art and artifice, into a unified structure.

The fold-over symmetry of many mirror designs, dating as these do in the period A.D. 1–50, has been recognized as due to the influence of Roman art; an attempt is now made to tie the achievement more closely to that source, since in its barbaric fashion it reflects something of the delicacy of perception and execution, the serenity of mood, which characterizes that art in the Augustan age.

It is held to be probable that the popularity of the triskelar pattern in British art was due to its magical significance, and a neglected stone aniconic object carved with triskeles, found near Gloucester fifteen years ago, is regarded as important in this connexion.

The difficulty met with by students in working out the history of early Celtic patterns, and the regional distributions of such—which require us to neglect no decorated piece of Celtic metal-work of the period in the country—arises from the lack of any organized centre for such study. Each individual repeats the laborious task of his predecessors: search through the scattered literature, and visits to museums to see described but unillustrated examples in the hope that they may be relevant to his needs. The creation of a card index of early Celtic metal-work in Britain, then, is urged, accessible to all accredited workers, and preferably linked to some institution, so that when completed to date, it will be kept up to date. It is hoped that an English school of research on early Celtic art may grow up in connexion with the development of such an index; it is gratifying to record that such a school for Scottish Celtic art may be held to be already in being in Edinburgh.

PHYSIOLOGY OF THE CAPILLARIES

THE presidential address to Section I (Physiology), by Prof. H. P. Gilding, forms the preface to a whole day's discussion on "Body Water". A brief outline of capillary structure serves as introduction. The complex patterns of capillary networks differ from organ to organ. That seen in simple structures such as the mesentery, so widely portrayed, can be very misleading if this picture is taken as a model for the rest of the body. In most structures the arterioles and venules run together until their final ramification, when they separate; this is best seen in skeletal muscle. Here the arterioles and venules lie transverse to the longitudinal axis of the muscle fibres, and ultimately the arteriole separates from the venule in such a manner that the latter is draining blood from arterioles on either side of it, with longitudinal capillaries of between 0·43 and 1·35 mm. in length joining them. Thus, between two transverse arterioles or venules a distance of more than 2 mm. is commonly found.

These facts were sufficiently well known a hundred years ago to be described and depicted in standard text-books of that time; it is not a little surprising that factual knowledge so important in consideration of capillary function should have been neglected and forgotten. It will be obvious that in skeletal muscle the lengths of the longitudinal capillaries are several hundred times their breadth. If we consider the maintenance of muscle fibres, another significant point emerges; along a given muscle fibre, alternating areas approximately 2 mm. apart are richly supplied by arterial blood, while the portion of fibre between is served by increasingly venous blood. These facts must be borne in mind when dealing with capillary tissue exchanges.

The evidence for the view that there is a gradient of capillary permeability is briefly discussed and reasons advanced for the necessity of such a gradient.

Consideration of known capillary and venous pressures throws doubt on the popular view of arteriolar-capillary filtration and venular-capillary absorption. Venous pressures measured in the dorsum of the human foot in quiet standing give readings of about 90 mm. mercury; this high pressure must be reflected in the capillaries, and therefore prevailing hydrostatic pressures in the foot during standing are such that filtration should, theoretically, continuously predominate and result in œdema. Common experience shows that this is not so. Similar considerations hold for the condition of affairs in the abdominal cavity. The portal capillary pressures in the supine animal are known to be higher than elsewhere, and furthermore these vessels are more permeable to protein. In the erect human being, gravity will increase the venous and capillary pressures over and above that in the horizontal position. We can calculate, therefore, that the prevailing colloid osmotic pressures are differentially too low physically to re-absorb the fluid, which is usually assumed to be filtered at the arteriolar end of the vessels.

The concept of capillary permeability being dependent on pores of varying sizes is discussed and repudiated.

Modern work using radioactive isotopes to measure capillary permeability is reviewed and reasons advanced for considering endothelial permeability as being comparable to cell membranes in general.

PSYCHOLOGY AND THE LAITY

THE century between the two great Exhibitions has seen the emergence not only of the science but also of the profession of psychology, and this is the keynote of the presidential address of Prof. C. A. Mace to Section J (Psychology). A 'ministry of the mind' has been created which is in many respects parallel and co-ordinate with the 'ministry of the soul' and the 'ministry of the body'. The acceptance of responsibilities by the psychologist in education, in industry and in the personal lives of men might seem to constitute a challenge to the vested interests of sagacity and experience, and to threaten yet further restrictions on individual liberty.

The surest defence against the danger, if danger there be, lies in the education of an understanding but critical laity. It is, indeed, upon the existence of such a laity that the success of the new profession must depend. The psychologist works indirectly, since when principles of psychology need to be applied it is almost always the layman who has to apply them. If reassurance be needed, it may be found in some measure in the history of the science in Great Britain. It has its roots in British natural history. The story of its growth could almost be told through the lives of three generations of the Darwin family. Erasmus Darwin was the first of the moderns to conceive the science of psychology as an integral part of biology. His grandson Charles applied the methods of the experimental naturalist to psychological problems. The other distinguished grandson of Erasmus, Francis Galton, could fairly be described as the founder of modern experimental psychology, since in his work, more than elsewhere, may be found the beginnings of so many of the most vital contemporary lines of research. He was the first of the experimental human naturalists—a psychologist of the field as well as of the laboratory. Among our near contemporaries, Charles Myers belongs to the same intellectual lineage.

In this tradition two features are outstanding. Erasmus Darwin, Galton and Myers did much to bridge the chasms that divide the arts, the sciences and the technologies. All were men of science who worked in close association with the scientific laity. The future of psychology, perhaps more than that of any other science, depends upon the preservation of this British tradition—since it is both *by* the layman and *to* the layman that psychology is in the main applied.

There is, accordingly, a distinctive approach in psychological research. The need for 'multidisciplined operational research'—the combined attempt of many specialists to solve practical problems in a scientific way—is now widely recognized. But in psychological research the layman who possesses special and relevant experience is an essential member of the research team. In many such cases this relevant experience may be in the field of the arts or the technologies. This approach is important in so many of the problems of technological education. It is important, too, for the solution of the problems of 'consumer assimilation' of the results of scientific research in every field. The piling up of the unapplied findings of scientific research is due in the main to the lack of machinery for co-operation between those who make discoveries and those who can apply them. The problem is especially acute in the field of the human and social sciences. We need a new conception of the function of a psychological laboratory or institute for psychological research. Such an institute needs to combine the features of a laboratory with those of a field station—to which intelligent amateurs will come, not for ready-made solutions to their problems, but for working hypotheses to test in their lives and daily work.

The need for co-operation between professionals and the laity gives additional significance to the current demands that scientific findings should be expressed in the common language of all educated men. The psychologist most of all needs to be bilingual—using whatever technical terminology he prefers in his purely professional circles, but speaking also in the language of the common educated man. The demand is not exacting; because although psychology is a very difficult subject, it has nothing in it which cannot be expressed in language which an intelligent fifth-form schoolboy can readily understand. Psychologists do not write cryptic prescriptions. They have no secret remedies. All they know they can and must tell. The function of the professional psychologist is not to cultivate a mystery but to communicate understanding, first of all to parents, then to teachers, and then to all who in any way are concerned with the supervision and management of men. So to report the facts of science is in the British tradition. It is in virtue of this tradition that the British Association is a British association—an association of professionals and laymen.

MYCOLOGY OVER A CENTURY

A REVIEW of the advance of mycology over the past hundred years, which constitutes Prof. W. Brown's presidential address to Section K (Botany), must be to all intents and purposes a review of the whole subject as a branch of science. Taxonomic mycology had taken shape in the early part of the nineteenth century, at least as regards the larger fungi; but any scientific treatment of the much larger number of microfungi (including bacteria) was impossible so long as it was held that such small organisms arose by spontaneous generation. A little less than a hundred years ago Pasteur established the biological theory of fermentation and disease, and the parallel work of de Bary and the Tulasne brothers laid the foundations of modern mycology.

The earliest researches took the form of mapping out the life-cycles of fungi, with the ultimate object of fitting the group into the scheme of Hofmeister, which had already been shown to apply to all groups of plants from the Bryophytes upwards. The task was difficult, on account of the reduction and even elimination of sex organs in the higher members of the fungal series, and it was only towards the beginning of the twentieth century that advances in cytological technique made the complete elucidation of certain life-cycles possible. These studies form the basis of the modern classification of fungi and of views regarding their evolutionary descent.

Much work has arisen from the discovery of heterothallism in fungi. Many of them exist in two

forms (which may roughly be called male and female) and in general the life-cycle cannot be completed unless these two forms come together with resultant nuclear fusion. It has been possible, on this account, to adapt the Mendelian method of study to fungi (including yeasts), so that there is now a flourishing line of fungal genetics. Fungal species in general consist of a cluster of strains, and it is possible to produce new ones by suitable mating. In this way new strains with enhanced value for industrial purposes—for example, yeasts for brewing, strains of *Penicillium notatum* for penicillin manufacture—have been developed.

The smaller fungi, especially moulds and yeasts, offer many conveniences for research on cell metabolism and on respiration in particular. The process of alcoholic fermentation by yeast has the special interest that it is closely related to anaerobic respiration, which is known to precede the normal aerobic respiration characteristic of all animals and most plants. Hence the wide biological significance of yeast biochemistry. Biochemical studies of fungi and bacteria, important from the fundamental point of view apart from their industrial interest (as in the preparation of citric acid, acetone, glycerol, certain vitamins, etc.) have become very active in recent years in connexion with the search for antibiotic substances, such as penicillin and streptomycin.

Two lines of physiological research on fungi have interesting parallels elsewhere. One of these concerns the response of fungi to minimal traces of certain metallic elements (zinc, copper, manganese and others), a response which is comparable to that of many higher plants; the other concerns the requirement by fungi of small quantities of special organic substances (biotin, aneurin, etc.), some of which are related to vitamin B. This behaviour is comparable with the dependence of animals on a vitamin-containing diet.

The interrelations of fungi and other plants are many and varied. Mutualistic effects between micro-organisms largely determine their localization in Nature and the frequency of their occurrence, and have been much studied in relation to the biology of soils. Beneficial effects (symbiosis) between micro-organisms and higher plants are shown in the fungus roots (mycorrhiza) of many plants such as grow in soils of high humus content (heath plants, orchids, many forest trees). Nodulation of the roots of leguminous plants is another example, and this is of the greatest importance in connexion with soil fertility. Harmful effects, which are not always sharply distinguished from symbiosis, are seen in the wide range of plant diseases caused by fungi. The development of plant pathological research on a nation-wide scale is one of the major mycological advances of the period under review.

MID-CENTURY—RETROSPECT AND PROSPECT IN EDUCATION

IN his presidential address to Section L (Education), Sir Hector Hetherington points out that the development of public education in Great Britain over the past hundred years reflects the same impulses or ideas which have expressed themselves in the changing pattern of social, political and economic institutions and policies. The two dominating elements in that movement have been the coming to full maturity of the natural and applied sciences, and of the technological civilization founded thereon: and on the other hand, the wider operation of a principle best described by Dr. Gilbert Murray's word 'liberality'. The essential social history of the period is that of the effort to overcome the class divisions produced by the first impact of the Industrial Revolution, to diminish differences in economic status and in political responsibility, and therefore also in educational and social opportunity. The process has been gradual, undoctrinaire, experimental, controversial as to method but not as to broad objectives, and in the course of a hundred years has been carried a very long way.

The corresponding development in public education was influenced no doubt by the need of an expanding industry for more skilful, and therefore for better educated, workers, just as the movement fifty years ago towards wider secondary and technical education was influenced by the technical outpacing of Great Britain by Germany and the United States. But the main impulse undoubtedly was the force of the moral demand, and the main struggle was over the assertion of the State's direct responsibility. The State's concern for elementary education had been asserted in 1833. The State's full responsibility for it was not established until 1870. Its legalized and explicit participation in secondary education was not established until 1902, and its responsibility for the provision of a full educational experience—compulsory 'secondary education for all'—dates only from 1944.

Just as the century's changes in economic and political institutions and practice have left some obstinate problems still unsolved, so also in the field of education. Great progress has been made, beyond doubt; but it has been progress in the creation of opportunity rather than in its assured and effective use. Large material problems remain—a shortage of teachers and a scarcity of well-equipped schools. Perhaps even more urgent is the definition of the use to be made, especially for the non-academic pupil, of the longer school-life. At that stage vocational and technical education is of high personal and national importance. But the essence of the matter is to discover how best to use these instruments as an introduction to a free and intelligent participation in the interests and responsibilities of a civilized society. To that end, the linkage with voluntary adult education is of great significance.

The favourable elements in the situation are the gradual emergence not of a single organic structure of national education, but of closer and more co-operative relations between many different elements, old and new, government and voluntary, formal and informal, and the reinforcement of the State provision by youth services of all kinds. But it is important to recognize that under modern technological conditions there are strong influences making for mass emotion and mass action, and that the educational system has it in trust to preserve the values of a free society.

EXPERIMENTAL AGRICULTURE

DR. E. M. CROWTHER, president of Section M (Agriculture), points out that the first critical review of the difficulties in obtaining reliable information in experimental agriculture was published a century ago by J. F. W. Johnston, who held the post of chemist to the Agricultural Chemistry Association of Scotland. Johnston realized the

necessity for having at least two plots for each treatment and the advantages of comparing manures "both singly and in combination". Field experiments with single plots per treatment were still being made in Britain until well on into the present century, though replicated plots in systematic arrangements were employed on the Continent from 1880 onwards. The whole subject of agricultural experimentation was transformed around 1925 by R. A. Fisher, who established the necessity for a measure of randomization in assigning treatments to plots and showed how the precision of the experimental results could be estimated. The factorial design of experiment, developed by R. A. Fisher and F. Yates, provided one of the most generally useful patterns of field experiment. There is an urgent need for series of these experiments for settling practical problems and providing basic facts for laboratory investigations.

Scientific concepts are often used somewhat loosely in interpreting agricultural observations, although no means have yet been found for testing their relevance. The contrast between the deductive and the inductive approaches to soil fertility problems was well illustrated in the famous controversy a century ago between Liebig and Lawes. The difficulty of relating laboratory research to practical agriculture still remains. Many laboratory techniques are too elaborate to be applied to the large numbers of samples needed in modern field experiments and soil surveys. Agricultural research has its own version of a principle of indeterminacy—the more exacting the technique, the less adequate the conditions under which it can be employed. Sometimes the difficulty arises in the opposite direction. Physical and biochemical investigations on soil structure are held up through lack of soil samples in which contrasted structures have been produced under experimental control in rotation experiments with different kinds and length of ley. So far, the field experiments required have proved too difficult.

It is essential that field experimental work should not be wasted on matters of purely local and temporary concern, but should be planned to make the fullest use of, and to provide the best raw material for investigations in, other branches of agricultural science.

The problem of balancing the various lines of approach may be simplified, in research and in teaching, if it is realized that agricultural science does not seek to establish general principles from which agricultural practices may be deduced, but has a more modest aim. Agricultural science may be regarded as a search for patterns of performance to be fitted to suitable landscapes. Its starting-point is current practice in the region concerned or in a similar one. The features of many environments and the effects of most agricultural operations can be classified sufficiently well for forecasting the effects of moderate changes in practice, but it is unwise to make drastic innovations without pilot schemes and detailed experiments.

The final paragraph from the introduction to Johnston's "Experimental Agriculture", published in 1849, is still relevant to-day. "It is only by means of conjoined experiments in the field, the feeding-house and the laboratory—all made with equal care, conscientiousness and precision—that scientific agriculture can hereafter be with certainty advanced. If we have been long in getting upon the right road, we ought to advance the more heartily now we have found it."

THE SCOTTISH SCENE

IN his presidential address to the Conference of Delegates of Corresponding Societies, Dr. Douglas A. Allan points out that the systematic survey of any scene should begin with its rock foundations. The Scottish scene is composed of the Pre-Cambrian area of the Highlands, the older Palæozoics of the Southern Uplands, the Old Red Sandstone and Carboniferous of the Midland Valley, and the Tertiary volcanics of the Hebrides. These determine the distribution of basic economic minerals, and to a large extent the pattern of the scenery; but the final touches are due to the recent glaciation, from which the modern river-drainage system and the spread of soil layers derived. With amelioration of climate, belts of vegetation advanced across the country, to be followed by a variety of animals and, finally, man. Man the food-gatherer was succeeded by man the settler, with his specialists of priests and warriors. All can be traced through Scotland by arrowheads, beakers, brochs, vitrified forts, and a multitude of remains.

Roman police occupation south of the Forth and Clyde for roughly a hundred years is marked by roads and forts. Christianity came north-east from Ireland and north-west from the Continent, as evidenced by ruined chapels and treasured shrines, while the Vikings, at first pagan and later Christian, for fully four hundred years raided and settled on coasts and islands, leaving customs and language as well as boats and buildings as their contribution to the making of the land and its people. The Wars of Independence barred the way to English culture but developed links with the Baltic, the Low Countries and France, all of which left their mark on Scottish arts and crafts, industry and learning. The four Scottish Universities came into being between 1412 and 1582. The union of the Crowns in 1603 and of the Parliaments in 1707 led to peaceful development, save for the Wars of the Church and the two Jacobite risings. Then came the Industrial Revolution, and the exploitation of the mineral wealth of the Midland Valley, the tough man-power bred of a warlike tradition, and an ingenuity stimulated by a wealth of contacts overseas.

The characteristic devotion to learning, once peace and a modest economic stability were secured, was reflected in schools and colleges, scientific and learned societies, and private and corporate collecting of antiquarian and natural history specimens. There are some seventy museums stretching from Stranraer to the Shetlands, each of which in some degree houses and explains examples of the geology, botany, zoology and human history of their districts; and eight regimental ones telling their special story, inevitably extending far overseas. The societies and museums of Scotland thus collect and preserve not only material individually interesting and important, but also as a team present for to-day and to-morrow a facsimile and a synthesis of the land, its inhabitants, and its history. To their aid have come such official bodies as the Ministry of Works with its Inspectorate of Ancient Monuments, and such unofficial ones as the National Trust for Scotland for Places of Historic Interest or Natural Beauty, both of which, in one form or another, have instituted site museums in special areas. In 1947 it was recommended that a National Parks Commission for Scotland be established, with the aim of preserving stretches of country carefully chosen as typical examples of wild scenery.

The Forestry Commission, to which has been entrusted the task of restocking vast areas despoiled in the course of the two World Wars, has extended its service by providing national forest parks in those high-level parts of its estates where planting would be unprofitable. The preservation of scenes and woodlands calls for similar action to save their wild life, that is to say, precariously balanced assemblages of plants and animals. To attempt this there has come on the Scottish scene the new Nature Conservancy; but to achieve it will call for prolonged and conscientious observing, collecting and recording by a field force of amateurs. This is a clear call to action which the Corresponding Societies must not ignore.

NEWS and VIEWS

Genetics at Adelaide: Dr. D. G. Catcheside, F.R.S.

The Executive Committee of the Commonwealth Scientific and Industrial Research Organization has recently made arrangements for the strengthening of animal genetics in the School of Zoology of the University of Sydney, and has guaranteed to the University of Adelaide, for the first ten years, a chair of genetics which will be held at the Waite Agricultural Research Institute of that University, where a programme of plant breeding has been in existence for some years, and where a postgraduate school in plant genetics has been recently developing. Dr. D. G. Catcheside, reader in plant cytogenetics in the University of Cambridge, has accepted the new chair and will take up his duties in 1952. Dr. Catcheside graduated at King's College, London, in 1928 under Prof. R. Ruggles Gates. His first post was as assistant in botany in the University of Glasgow. He returned to King's College as assistant lecturer in 1931 and later became lecturer. R. P. Gregory had started the teaching of cytology and genetics at Cambridge before the First World War. After Gregory's death at the end of 1918, Prof. F. T. Brooks, then lecturer in mycology, carried on the work until Dr. Catcheside arrived to relieve him. Under Dr. Catcheside's leadership the subject rapidly developed at Cambridge and became a prominent part in the training of students in botany for the Natural Sciences Tripos. Dr. Catcheside's growing reputation attracted an increasing number of research students to Cambridge. In 1944 he was elected to a fellowship at Trinity College, Cambridge, and in 1950 he was made reader in plant cytogenetics. In 1951 he was elected to fellowship of the Royal Society. His interests are wide and include the cytology and genetics of *Oenothera*, the cytological and genetical effects of ionizing radiation, and the biochemical genetics of *Neurospora*. His work is well known in the United States, where he spent the year 1936–37 as a Rockefeller Foundation Fellow at the California Institute of Technology under Prof. T. H. Morgan and his sabbatical leave at Stanford University in 1947. Dr. Catcheside's promotion to the chair at Adelaide will be a serious loss to the Botany School at Cambridge.

Astronomy in the University of Manchester: Prof. Z. Kopal

Dr. Zdenek Kopal has been appointed to a newly created chair of astronomy in the University of Manchester. Dr. Kopal was born in Czechoslovakia in 1914 and graduated as a doctor of science of the Charles University, Prague, in June 1937. He held the Ernest Denis Fellowship of the Czechoslovak Government during January–June 1938 at Cambridge, working under the late Sir Arthur Eddington. From September 1938 he held a research fellowship at the Harvard College Observatory, Cambridge, Massachusetts, becoming a research associate in Harvard University in 1940. During August 1942–June 1946 Dr. Kopal was on leave of absence, undertaking war work at the Massachusetts Institute of Technology, where he became in 1946 a research associate; in 1947 an associate professor of applied mathematics; and in July 1949 head of the Institute's Computation Laboratory. Since 1949 he has also been an honorary lecturer at Harvard University. The majority of the large number of scientific papers published by Dr. Kopal have dealt with the theory and observation of variable stars. His monograph, "An Introduction to the Study of Eclipsing Variables", is the standard work on the subject. He has also studied the oscillations of various stellar models. He became a naturalized citizen of the United States in 1948, since when he has been chairman of the Commission on Close Binary Systems of the International Astronomical Union and a member of the Commissions on Meteors and on Variable Stars, as well as of the sub-committee on the upper atmosphere of the National Advisory Committee on Aeronautics of the United States. Since 1950 he has been consulting editor of the *Journal of Mathematics and Physics*.

Imperial College of Tropical Agriculture: Mr. A. B. Killick, C.M.G.

Mr. A. B. Killick, at present director of agriculture in Uganda, has been appointed professor of agriculture and director of studies at the Imperial College of Tropical Agriculture, Trinidad, British West Indies, and is expected to take up his duties early in 1952. Mr. Killick graduated from Wye College (University of London) and is also a past student of the Imperial College of Tropical Agriculture. He spent the early part of his career in Uganda, where he served as an agricultural officer from 1924 until 1936. He was then appointed deputy director of agriculture in Trinidad, leaving there in 1939 to take up a similar appointment in Tanganyika; in 1947 he was appointed to his present post in Uganda.

Lorenz Oken (1779–1851)

Despite his remarkable learning, Lorenz Oken, who died a century ago, on August 11, 1851, is remembered chiefly as the exponent of doctrines long since abandoned. He was born at Bohlsbach in Swabia on August 1, 1779. When a medical student of two years standing, he published his "Grundriss der Naturphilosophie" (1802)—an attempt to construct a biology which reflected the action of the mind. Regarding man as the summit and crown of Nature, his exaltation of the male led him to declare that "Ideally every child should be a boy". Though he was groping toward something which he understood but imperfectly, he showed some conception of protoplasm and cells in his essay "Über das Universum" (1808), describing the first transition "from the Inorganic into the Organic" as "the transformation into a *cell*".

Oken advanced the science of embryology and founded the biological journal *Isis* (1816–48), an organ of wide scope responsible for an "encyclopædic diffusion of knowledge". By promoting the first German Congress of Naturalists and Physicians in 1822, he initiated the annual meetings of men of science which now have their counterparts all over the world. He originated the vertebral theory of the skull, later expounded by Goethe and finally exploded by Huxley in 1858. He never knew financial security, and his candour earned him political enemies who were responsible for his dismissal from Jena and Munich. Given a professorship in the newly founded University of Zurich in 1833, he produced his thirteen-volume "Allgemeine Naturgeschichte". Though frequently in the wrong, Oken was an original thinker and teacher who stimulated others to scientific endeavour. His real name was 'Ockenfuss'.

Science and Religion

THE controversy between truth as revealed by 'religious insight' and the scientific attitude is clearly brought out in two recent articles in *The Fortnightly* (No. 1,015; July 1951). In a review of Prof. Barbara Wootton's book, "The Testament of Social Science", J. B. Coates declares that knowledge of a scientific kind is on an inferior level of being to the existential world of the creative spirit, the world of value and of communion between persons, and should be recognized as being instrumental to it. Coates implies that the tendency to make science supreme over religion and philosophy is usually an evidence of spiritual debasement as it is frequently marked by intellectual arrogance. In her reply to Mr. Coates, Prof. Barbara Wootton argues much more tolerantly that Mr. Coates has attacked a windmill of his own making and that both unique personal experience and facts collected by scientific probing are essential if man's behaviour and values are to be understood. On a subject of such importance it is hoped that these articles will lead to comments by others.

East African Industrial Research Board

THE eighth annual report of the East African Industrial Research Board, covering the year ended December 31, 1950, indicates that no new major investigations have been initiated, the technical staff having been fully occupied on investigations already in hand. Much analytical work has also been undertaken and many mineral ores again assayed on behalf of the Geological Survey of Uganda. Kyanite is now being calcined locally to give the more valuable product, mullite, from which a substantial production of high-grade refractories is expected to develop. The production of fired clay building materials on a much larger scale in the Nairobi area is imminent. Further work has been done on the manufacture of Broseley tiles from Kiambu sub-soil and finely ground quarry debris, and a small pilot plant is producing decorated domestic pottery using brushwork on a raw glaze, although the only large pottery operating in Kenya has closed down its plant. Production of soda-phosphate fertilizer is now established commercially, but further work is being carried out to eliminate a tendency of the briquettes to collapse on warming when the reagents are fired in a brick kiln, with consequent difficulty in obtaining even firing conditions. Further research has been carried out on the so-called 'fermentation' of fresh pyrethrum flowers to ascertain whether a special treatment could be applied to the freshly picked flower heads which would substantially increase their pyrethrin content. It appears, however, that unless the action is closely controlled, no marked increase in pyrethrin content can be expected, and such control could not easily be applied on a large scale.

Commonwealth Index of Scientific Translations

FOLLOWING resolutions passed at the British Commonwealth Scientific Official Conference in 1946 and the Royal Society Scientific Information Conference in 1948, the British Commonwealth of Nations Scientific Liaison Offices in London have started a Commonwealth index of scientific translations. Each of the Commonwealth countries has or will have an agency which is to maintain a central index of translations into English of published scientific papers, reports and journal articles which have been made by various organizations within the Commonwealth. Each agency collects details of translations made by the organizations in its own country which are co-operating in the scheme; the information is then passed to British Commonwealth of Nations Scientific Liaison Offices, London, where index cards are prepared and sent out to the agencies within the Commonwealth. Persons wishing to know if a certain translation is available should apply to the agency in their own country. So far the following agencies have been established: *United Kingdom*, ASLIB, 4 Palace Gate, London, W.8; *Canada*, Information Division, National Research Council, Ottawa; *Australia*, Information Service, Commonwealth Scientific and Industrial Research Organization, 314 Albert Street, East Melbourne; *New Zealand*, Information Bureau, Department of Scientific and Industrial Research, Wellington; *India*, Deputy Secretary, Ministry of Natural Resources and Scientific Research, Secretariat, New Delhi.

Preservation of Glass from Corrosion

A SHORT note by Max Unwin on the preservation of glass from the effects of weathering is contained in the April issue of the *Museums Journal*. In many instances, iridescence in glass is caused by carbon dioxide in the air or soil forming carbonic acid. This combines with the alkaline constituents of glass and causes decomposition of the surface which may ultimately lead to complete disintegration. The iridescent appearance is the result of an optical effect, and the lamination of the decayed surface may be eliminated by impregnating the surface with a medium optically continuous with the glass itself. The resin now used for this purpose is a polyvinyl acetate dissolved in toluol, prepared by Messrs. Hopkin and Williams, Ltd. Impregnation is effected by dipping the object for a short time in the resin solution.

Oil and Colour Chemists' Association

THE membership of the Oil and Colour Chemists' Association has increased so rapidly, and its *Journal*, published monthly, has so increased in size, that it has become necessary to establish a permanent office. Mr. R. H. Hamblin has been appointed general secretary, both to look after the general affairs of the Association and to deal with the editorial side of the *Journal*. All business inquiries and communications should therefore be addressed to him at the Association's new offices, Memorial Hall, Farringdon Street, London, E.C.4. The 1951 Conference of the

Association was held at Scarborough during May 29–June 2, and the technical side took the form of a symposium on pigment/vehicle relationships. The following honorary officers were appointed for the current year: *President*, Mr. L. O. Kekwick; *Hon. Secretary*, Mr. R. S. Law; *Hon. Treasurer*, Mr. N. A. Bennett; *Hon. Editor of the Journal*, Dr. R. F. Bowles.

Summer School on the Technology of Synthetic Resin Adhesives

A summer school on the technology of synthetic resin adhesives, organized by Aero Research, Ltd., Duxford, Cambridge, will be held during September 23–29 at Cambridge. There will be a choice of two courses: synthetic resin adhesives for the woodworking industries; and synthetic resin adhesives for the engineering, electrical manufacturing and allied industries. Lectures will be given in the University Engineering Department Lecture Theatre in the mornings, and most afternoons will be devoted to practical work and demonstrations at the factory at Duxford. Accommodation has been arranged at St. Catharine's College, Cambridge, and the inclusive fee for the school is 10 guineas. Further details can be obtained from Aero Research, Ltd., Duxford, Cambridge.

Conference of the International Association of University Professors and Lecturers

The sixth conference of university teachers, organized by the International Association of University Professors and Lecturers, will be held in Nice during September 20–24 and will be open to members of the Association and to all others interested. The conference will meet under the chairmanship of Prof. A. Portmann, of the University of Basle, and the vice-chairmanship of Prof. F. Vito, of the Catholic University of Milan. The general aim, as of all the activities of the Association, is to foster the development of an academic fraternity, across the boundary lines of faculties, among the university teachers of all countries. In particular, three topics will be considered at the conference: academic freedom; relation between research in industry and in the universities; and the status of the university teacher. The address of the conference will be Centre Universitaire Méditerranéen, 65 Promenade des Anglais, Nice. The registration fee is 10*s*. Further details can be obtained from Mrs. Cecil, Secretary, I.A.U.P.L., 13 Old Square, Lincoln's Inn, London, W.C.2.

University of London

The title of professor in the University of London has been conferred on the following in respect of the posts held by them at the Royal Veterinary College, London: Prof. H. Burrow, professor of veterinary medicine; and Prof. N. J. Scorgie, professor of veterinary hygiene. The title of reader in inorganic chemistry in the University has been conferred on Dr. A. J. E. Welch, in respect of the post held by him at the Imperial College of Science and Technology, London.

Clayton Awards for 1951 of the Institution of Mechanical Engineers

Under the Clayton Bequest, the Institution of Mechanical Engineers has recently made the following awards for 1951, amounting in all to about £3,800, for postgraduate training or research in mechanical engineering: *Clayton Fellowships*: B. E. L. Deckker (Birmingham), F. Ellis (London), J. Halling (Mitcham, Surrey), J. Houghton (Coventry), D. Howe (Bletchley, Bucks), G. Moss (London), H. Naylor (Baildon, Yorks) and M. Ruddick (Grays, Essex). *Clayton Grants*: J. Huddart (London), D. R. S. Rabley (Plymouth) and N. D. Thomson (Sheffield).

Announcements

We regret to announce the death of Prof. A. J. Allmand, F.R.S., lately professor of chemistry in King's College, University of London, which occurred on August 4, aged sixty-six.

Prof. C. A. Coulson, professor of theoretical physics in King's College, University of London, has been elected Rouse Ball professor of mathematics in the University of Oxford as from January 1, 1952. Prof. Coulson went to his present post in 1947 (see *Nature*, May 10, 1947, p. 632).

Dr. Andrew Wilson, reader in applied pharmacology in University College, London, has been appointed professor of pharmacology in the University of Liverpool.

A summer school on relaxation methods will be held in the Imperial College of Science and Technology, London, S.W.7, during September 3–21. The school will be on similar lines to that held last year and will cover the numerical solution of linear algebraic equations, framework problems, Laplace's and Poisson's equations, the biharmonic equation, eigenvalue problems, the heat-conduction equation, etc. The fee for the course will be £10. Further details can be obtained from D. N. de G. Allen, at the Imperial College.

A conference organized by the Food, Agriculture and Fine Chemicals Groups of the Society of Chemical Industry on "Problems Arising from the Use of Chemicals in Food" will be held at the Wellcome Research Institution, 183–193 Euston Road, London, N.W.1, during September 27–28. Forms of registration for the conference can be obtained from the Assistant Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1; the registration fee is 10*s*. for members of the Society of Chemical Industry and £2 for non-members.

A colloquium on recent advances in the study of cosmic radiation will be held in the School of Cosmic Physics, Dublin Institute for Advanced Studies, during September 25–27. Formal lectures will be given in the mornings by Dr. G. D. Rochester, Dr. C. Ó Ceallaigh and Dr. E. P. George. In the afternoons there will be specialized discussions to which contributions will be made by the visiting lecturers and members of the School. Further particulars can be obtained from the Registrar of the Institute.

Imperial Smelting Corporation, Ltd., are now producing fluorine gas compressed into steel cylinders at 400 lb./sq. in. pressure at their Avonmouth works. Inquiries should be directed to the Company at 37 Dover Street, London, W.1.

In connexion with the review of Oliver Heaviside's "Electromagnetic Theory" published in *Nature* of July 28, p. 136, Messrs. E. and F. N. Spon, Ltd., state that this publication is now issued only by them, and they have the complete copyright in it.

SCIENCE IN BERLIN

DURING the seven days beginning May 24, a scientific conference was held in Berlin and was attended by delegates from many parts of the world. It was held under the patronage of the Burgomaster of Berlin, Prof. Ernst Reuter; the Senate of the City of Berlin; and the Plenipotentiary of the German Federal Republic, Dr. Heinrich Vockel. The Conference was organized with the support of the Gesellschaft Deutscher Chemiker, and its president, Prof. K. Ziegler, paid tribute to Prof. J. D'Ans who, as president of the Berlin branch of the Gesellschaft, had been largely responsible for the idea of holding the Conference and for its organization. The bodies which acted as hosts were: the Freie Universität Berlin, the Technische Universität Berlin, the Deutsche Forschungshochschule Berlin-Dahlem, the Ortsverband der Gesellschaft Deutscher Chemiker and the Berliner Physikalische Gesellschaft.

The Conference demonstrated very clearly that Berlin again has an important part to play in academic and scientific affairs, and it provided a valuable occasion for Berlin scientific workers to meet their colleagues from other parts of Germany and to discuss their scientific problems. It was the first major scientific conference to have been held in Berlin after the War, since most of the recent conferences have been held in the Federal Republic of Western Germany. It was attended by students of the Berlin Universities, including the Humboldt University in the Eastern Sector. Nearly 2,500 tickets were sold to participants, about 800 of these to residents of the Eastern Zone of Germany or the Eastern Sector of Berlin.

The scientific papers were formally divided into two main groups: the first on chemical problems in living processes; the second on problems of atomic physics, molecular physics and cosmogony. The large number of papers contributed at the Conference (some sixty or so in number) covered a wide range of chemistry, physics and physical techniques; eight of the papers were from the Eastern Zone of Germany and four from the Eastern Sector of Berlin.

The visiting foreign men of science, many of whom read papers, were: Prof. H. J. Hildebrand, University of California; Dr. J. R. Johnson, Cornell University; Dr. Miller, Minnesota Mining and Metallurgical Corporation; Prof. P. Niggli, Technische Hochschule, Zurich; Prof. J. A. Hedvall, Göteborg; Prof. R. Domenjoz, Saarbrücken; H. Nitschmann, Bern; Prof. H. S. W. Massey, London; Dr. F. P. Bowden, Cambridge; Prof. Chrétien, Paris.

The Conference was held in the premises of the Technical University (Berlin-Charlottenburg), and at the ceremonial gathering the rector, Prof. W. Pflaum, laid stress on the important part that the fundamental and exact sciences play in technology. Dr. Vockel said that he envied the natural scientists their comparatively simple task of discovering the natural laws which govern the physical world. He appealed for their understanding of, and sympathy for, the politician who is attempting the difficult and urgent task of discovering the laws which govern the social order. Dr. Tiburtius, as Senator for Education in the City of Berlin, spoke of the attitude of the State towards science, which should not be to harness it for political ends, but to co-operate with scientific workers and to assist them in the free pursuit of their researches. The other speakers were Prof. M. von Laue, president of the Kaiser-Wilhelm-Institut, Berlin-Dahlem; Prof. Ziegler; Prof. Hans von Kress, rector of the Free University. Prof. C. Ramsauer, president of the Berlin Physical Society, gave an account of the part which Berlin scientific men have played, particularly in modern physics and chemistry. Measured by any yardstick this is impressive, and it was interesting to note that of the total of thirty-four Nobel Prizes which have been awarded to German physicists and chemists, eleven were gained by Berlin scientific workers. Prof. P. Niggli (Switzerland) spoke on behalf of the foreign men of science and paid tribute to Berlin's record in the natural sciences.

The first session began with a paper on photosynthesis by Prof. O. Warburg, and the physics session on radioactivity, which was under the chairmanship of Prof. J. D'Ans and Prof. M. von Laue, was opened with a paper from Prof. O. Hahn. This opening session was attended by Major-General G. K. Bourne, General Officer Commanding Berlin (British Sector), by Dr. Vockel, and by representatives of the British, American and French Scientific Research Divisions.

Those attending the Conference worked hard during the day, and in the evenings were entertained at various social functions, both official and private. These included a reception given by Dr. Vockel; an evening at the ballet "Abraxas", followed by a reception given by the Senator for Education, the Rector of the Technical University and the Rector of the Free University. At this reception a presentation was made to Herr Werner Egk, composer of the ballet. A reception was also given by the Mayor and Senate of Berlin. In addition to this, there were student gatherings and entertainments. Visits were paid to various research laboratories, many of which are admirably equipped and which are carrying out work of a high standard.

The Conference was held in an atmosphere of lively interest and enthusiasm, and it was impressive to see how science can transcend all political difficulties. The attendance was very large; in the physics session, for example, it was well over a thousand, a big proportion being students. The whole Conference was admirably organized, and it reflects great credit on Prof. D'Ans and the organizing committees. It is clear that science in Berlin is very much alive, and tribute must be paid to the devotion and courage of those who have built it up under such difficult conditions.

F. P. BOWDEN

A CENTURY OF DEVELOPMENTS IN ENGINEERING

A "JOINT Engineering Conference, 1951", organized by the Institutions of Civil, Mechanical, and Electrical Engineers, was held in London during June 4–15. A large number of papers reviewing the development of different branches of engineering during the past hundred years were read.

One group of papers dealt with mechanical engineering developments in the mercantile marine, on the railways, in the gas industry, in electricity power stations, in road transport vehicles and in the iron and steel industry. Mr. R. A. Crowe outlined the

development of ship propulsion from the day when the naval "Seamanship Manual" stated categorically that "there is no greater fallacy than to suppose that ships can be navigated on long voyages without masts and sails", to the most recent developments in the application of gas turbines to marine propulsion. He believes that for many years to come the steam turbine is likely to remain unchallenged for the propulsion of large passenger liners. Mr. R. A. Riddles reviewed progress in railway mechanical engineering from the early pioneering days of the Stockton and Darlington Railway, the first public railway to employ locomotive traction, to the many attempts to improve the thermal efficiency of steam traction which have been made during the first half of the present century. Mr. F. M. Birks dealt with technical advances in the gas industry. He explained the advances from manually charged retorts to the successfully developed Glover–West and Woodall–Duckham systems of continuous vertical retorts, which are now responsible for about one-half of the gas output of the industry. A ton of Durham coal now yields 74 therms of gas, 20 therms of tar and 165 therms of saleable coke, the total products for sale having 86 per cent of the thermal value of the coal. Mr. Birks thinks that, economically, the gas industry has a promising future, as it is able to convert thermal energy for cooking purposes at a capital cost considerably less than half that required by any other system of distributed energy. Mr. Bask, in discussing mechanical plant for electricity power stations, said that fifty-three new power stations have been designed in Great Britain to come into operation during the period 1946–56. Anxiety about the rate of extraction of coal, oil and natural gases is giving a special impetus to the use of water-power resources and the more efficient use of other sources of power. Economic studies appear to justify the use of heat from atomic piles for base-load stations, and it seems that atomic piles in association with steam plant may become practicable in the near future.

Another group of papers dealt with hydro-electric power schemes and power station design and construction, the generation, transmission and distribution of electricity, applications of electricity to sea transport, the development and use of gas-pressure cables for high-voltage systems in Great Britain, electric traction and signalling, telecommunications, air radio, electrical measuring instruments, the British television service, radio masts and towers and progress in electric lighting.

Sir John Hacking, in his paper on the generation, transmission and distribution of electricity, said he believes that during the next twenty years there will be more development in the use of water power than in the use of any other kind of energy for electrical generation. Tidal power schemes such as the Severn Barrage have been investigated, but they suffer from the disadvantage that it is not possible to obtain a reliable output during peak-load hours without some system of energy storage. On the other hand, the use of gas turbines would have the advantage that they can be started up rapidly for use during peak hours; they are not likely to become competitive in Great Britain until pulverized coal can be used as a fuel in the place of oil. Experiments are also being carried out at the present time to make use of wind power.

Mr. J. E. Goodall and Mr. D. B. Irving described the development of gas-pressure cables for high-voltage systems. The first experimental installation using high gas-pressure to suppress ionization, or the reaction involving re-combination of ions, passed its tests in November 1931, and the first commercial installation of this type of cable in the world was carried out in the following year in London. The main mechanical difficulties were encountered in sealing the ends; but these have now been largely overcome, and different manufacturers are standardizing the details of these cables.

Sir Stanley Angwin traced the development of telecommunications during the past hundred years, Air Commodore Cadell and Dr. O'Kane discussed the use of radio aids in flying, and Sir Archibald Gill described the ever-increasing use made of electrical devices on board ship. Sir Stanley Angwin pointed out that the electric telegraph handled 48,600 messages during the year 1851, whereas in 1948 that number had increased by more than a thousand times. The comparable figures for the telephone service show that the first exchange with eight subscribers was opened in 1879, the total number of subscribers increasing to 3,300,000 in 1939 and 5,200,000 at the present time. Dr. S. Whitehead reviewed the development of electrical measuring instruments. He pointed out that the early history of electrical measurements is virtually the history of physical science. Electrical measurements made many of the discoveries possible, which in turn led to better instruments. With the development of the electrical industry came a further great demand for reliable electrical measurements, until to-day there are very few measurements in which electricity does not or could not play a part. Sir Noel Ashbridge described the developments that led to the establishment of the British television service. He recalled that, in 1908, A. A. Campbell Swinton, in a letter in *Nature*, outlined a proposed method of television strikingly similar to that now in use. Sir Noel discussed the difficulties in the siting of television transmitters, and, turning to the future, thought that the reasons which militated against stereoscopic cinematography operate even more strongly against stereoscopic television. Colour transmission, on the other hand, presents an attractive field for development. It is now possible to transmit a satisfying picture of adequate detail in colour within the same spectrum space as a picture of apparently similar detail in monochrome.

Mr. R. D. Ackerley outlined the development of electric lighting from the discovery of the electric arc by Sir Humphry Davy to the construction of the largest light source in the world, a 4,000-amp. 600-kW. arc lamp for anti-aircraft use in the Second World War. The greatly improved efficiencies of modern lamps were mentioned, and Mr. Ackerley foresees developments in high-pressure mercury vapour lamps for better street lighting, and an increase in efficiency and a fall in the cost of fluorescent lamps. Mr. C. O. Boyse, in his paper on radio masts and towers, described the co-operation between the radio engineer and the structural engineer which is necessary in the design of these structures. He considers that the installation at Rugby, which was built in 1923 and consists of a dozen 820-ft. high masts, is still one of the outstanding achievements in this field.

Yet another group of papers dealt with permanent-way developments, underground-railway planning and railway bridges, ports, harbours and dry docks, road planning and safety, a number of public-health topics and the development and design of aircraft

structures, and planning and construction of airfields. Mr. Everard, Mr. Anderson and Mr. Sutherland Campbell, the authors of the first of these papers, pointed out that underground railways provide a second plane of traffic with the highest known capacity for handling large crowds. They can handle more than 100,000 people per rush hour in two directions of traffic at an average speed of 20–25 m.p.h. The figures of journeys by public transport per year per head of population were given as: Paris 400, New York 462, London 500. No large-span railway bridge has been built in Great Britain since the Forth Bridge (1890). The greatest problem in connexion with railway bridges in Britain is their maintenance, the railway executive being responsible for a total of more than sixty-two thousand bridges. Mr. Leighton and Mr. Guthrie Brown discussed the port facilities of Britain and the great contribution engineers have also made to the handling of bulk cargoes like grain, seeds, coal and petroleum. There are now thirty-two major dry docks in the world, ten of which are within the British Commonwealth. Any forecast of future dry docks is linked with the average increase in the size of commercial vessels, particularly if the tendency of an increasing ratio of beam to length continues. Mr. G. T. Bennett, in his paper on road safety and planning, quoted an estimate that the total cost to Great Britain of road accidents was £100 millions in 1946, without accounting for losses due to delay on the roads. He pointed out that Great Britain depends for prosperity largely upon the exploitation of its geographical position, the short distances between ports and centres of industry favouring entrepot trade and exports. He advocated strongly the investment of capital in road improvement to cheapen production costs.

Mr. H. J. B. Manzoni, Mr. H. F. Cronin and Mr. D. M. Watson read three papers on the related topics of public-health engineering, water supplies and sewage disposal. Mr. Manzoni reviewed the insanitary state of most towns and cities in the early part of the last century and the great advances which have been made since then. He gave an indication of the magnitude of the problem of refuse disposal by quoting the figure of 14 million tons as the annual quantity of refuse collected by local authorities in England and Wales just before the Second World War. He also referred to the problem of district heating. This is the most economical method for a large estate of houses in which the whole of each house is heated; the cost is greater, however, than the cost of coal fires to heat only one, or at most two, of the rooms in each house.

Papers on engineering education and training which were read at the Conference have already been reviewed separately in *Nature* of July 7, p. 14.

E. K. Frankl

THE MUSEUMS ASSOCIATION

ANNUAL CONFERENCE

THE fifty-seventh annual conference of the Museums Association was held in Belfast during June 18–22 under the presidency of Mr. S. D. Cleveland, deputy director, City Art Gallery, Manchester. The theme of the Conference in this Festival Year was "The Museum as Mirror of British Achievement in Art and Science". About three hundred delegates attended, including representatives of the French museum movement, and others from Unesco, and from Australia, Canada, Mauritius, Egypt and the United States.

The presidential address, on "Association Reflections", was a survey of the activities of the Association since 1939. Mr. Cleveland reviewed in some detail the work carried out by museums and art galleries during the difficult war years, and felt that, despite the handicaps, the period was a stimulating one in the museum movement. With regard to the future, Mr. Cleveland considered that, in adopting a constitution more in keeping with the present policy of the Association as primarily a professional organization, the present standards of curatorship necessary for a public service would be maintained and indeed improved.

Mr. J. A. S. Stendall, director of the Museum and Art Gallery, Belfast, after outlining the history of museums in Northern Ireland, described the modern display methods adopted at Belfast during the past few years. The material has been re-arranged so as to tell a story, colour effects have been used lavishly, and fluorescent lighting is combined with the earlier tungsten lamps. Reference was made to the projected museum of Ulster life and tradition which is to be established in the grounds of Belfast Castle.

Dr. D. Dilwyn John, director of the National Museum of Wales, recalling the theme of the Conference, reminded the audience that "a mirror reflects things outside itself and thus museums do mirror British achievements which are not in themselves museum achievements". As an example he took a specimen of *Glossopteris*, a fossil fern from the Antarctic, collected at the side of the Beardmore Glacier by Wilson when returning with Scott from the South Pole. Eventually the specimens were found and shown in the British Museum (Natural History). The fern proved the existence in former times of a great southern continent. But the fossil has another value, for it reflects and mirrors a great British achievement.

Dividing the work of museums into display, curatorial activity and study, Dr. John showed how present display methods consist of starting with the familiar and gradually passing step by step to the less well-known. The safety and preservation of rare specimens are among the most important of curatorial activities, while from the study of great natural history collections springs new knowledge and understanding. Dr. John stressed that a museum man, working in a natural history museum, may be led on from his fundamental work to considerations of the widest interest and to problems which are world wide.

Dr. F. Sherwood Taylor, director of the Science Museum, London, considered that local museums should show illustrations of the physical sciences even if only as temporary displays. He considered that experiments are preferable to static apparatus and stressed that museums should not attempt what has already been demonstrated in schools. He also felt it more desirable to illustrate local industries rather than the simple laws of physical sciences.

The Conference was of particular importance in that it not only reflected the continued progress of museums in their recovery from war damage and reorganization, but also demonstrated the new aims and ideas, techniques and activities which are now evident, and which have greatly stimulated popular interest in, and change of outlook towards, the function of public museums and art galleries.

INSTITUTE OF PHYSICS

ANNUAL GENERAL MEETING

At the thirty-first annual general meeting of the Institute of Physics, held on May 16 at the Institute's House, 47 Belgrave Square, London, S.W.1, the following were elected to take office on October 1: *President*, Prof. W. E. Curtis; *Vice-President*, Dr. J. Topping; *Honorary Treasurer*, Mr. E. R. Davies; *Honorary Secretary*, Dr. B. P. Dudding; *New Ordinary Members of the Board*, Mr. O. W. Humphreys and Prof. S. H. Piper. Dr. A. B. Wood and Mr. C. G. Wynne join the Board as the new representatives of the Physical Society.

The thirty-first annual report of the Board, covering the work of the Institute during 1950, was adopted at the meeting. It records continued progress. The Board met six times and its various standing committees twenty-one times during the year. The total membership increased by 201 to 3,858, though there was a considerable—and from a financial point of view an undesirable—decrease in the number of subscribers. Slightly fewer applications for election or transfer to the various grades of membership of the Institute were received during 1950 than in the previous year. From the detailed analysis of membership given in the report, the effect of the changes made in the regulations in 1949 can clearly be seen. These changes allowed for the creation of the grade of graduate and the raising of the minimum ages of entry and the lengthening of the periods of experience required for grades of fellow and associate. It has recently been decided to establish a graduateship examination, and the regulations and syllabus, which have been drawn up by the Institute's Education Committee, will shortly be issued.

Details of the activities of the eight branches and the seven specialist subject groups of the Institute are listed in the report. The Australian Branch, which consists of five divisions, held thirty-three meetings for lectures and discussions and, in addition, a four-day conference in Sydney during November on photometry and its applications. The Manchester and District Branch, in collaboration with the British Society of Rheology, held a summer conference on the physics of lubrication, and the Midland Branch held a two-day conference in Birmingham on vacuum physics at which several firms exhibited various types of vacuum equipment. Under the auspices of the Scottish Branch, well-attended courses of lectures on atomic and nuclear physics, and on industrial and medical applications of atomic physics, were given at the University of Glasgow and University College, Dundee, respectively.

Most of the groups, in addition to holding lecture meetings, organized or participated in conferences lasting over several days. The Education Group discussed physics in schools; the Electronics Group, gas discharge tubes; the Stress Analysis Group, electric strain-gauge techniques; and the X-Ray Analysis Group, both the production and application of high-intensity X-ray beams, and the development and application of Fourier methods in crystal structure analysis. The Industrial Radiology Group held a five-day summer meeting and exhibition in London in association with the Sixth International Congress of Radiology. This group has also been responsible for the production of memoranda on the training of industrial radiographers and on radiological units, in addition to the publication of a second edition of the "Handbook of Industrial Radiology".

At the suggestion of the British Iron and Steel Research Association, the Institute organized a conference on some aspects of fluid flow. This was held at the British Iron and Steel Federation's house, Ashorne Hill, near Leamington Spa, during October 25–28 and was attended by about a hundred and fifty, of whom one-third were members of the Institute. The papers presented and a summary of the proceedings are being published in book form by Messrs. Edward Arnold and Co.

The report mentions that thirty-three technical colleges have now received official recognition, after inspection by the Institute, as institutions suitable for the training of physicists. During 1950, for the first time candidates were presented for the Higher National Certificate in Applied Physics issued jointly by the Ministry of Education and the Institute, and four of the six candidates were successful. For the Ordinary National Certificate there were sixty-four candidates from England and Wales; thirty-eight were successful. Seven candidates entered for the first examination to be held in Scotland, and six were successful.

The Institute has continued to take an active part in the discussions by various bodies on the training of technicians and on higher technological education. The Board has decided to discontinue the Institute's Certificate in Laboratory Arts, and no further examinations will be held after December 1951. The proposals put forward by the City and Guilds of London Institute's Advisory Committee on the education and training of laboratory technicians for an appropriate examination under the auspices of that Institute are regarded by the Board as very satisfactory and suitable for replacing the Certificate examination.

The report states that the new monthly periodical, *British Journal of Applied Physics*, which began publication in January 1950, has been well received. Both in this journal and in the *Journal of Scientific Instruments*, a high standard has been maintained. Other publications during 1950 include a monthly *Bulletin* circulated to members; "Acceleration of Particles to High Energies", in the "Physics in Industry" series, containing the papers delivered at the symposium held in 1949 by the Electronics Group; and a revised and enlarged edition of "Notes on the Preparation of Contributions to the Institute's Journals and Other Publications".

The Institute has kept in close and constant touch with the American Institute of Physics, and is represented on many joint committees and bodies, including committees of the Royal Society and the British Standards Institution.

A growing number of inquiries from members and others about salaries, conditions of service, consulting fees, insurance and radiation hazards, and other professional matters were received and dealt with by the executive officers of the Institute. At the annual conference of the Branch and Group officers, the Board was requested to develop further the Institute's already extensive professional activities and to include a greater interest in the economic status of physicists, particularly those who are teachers in schools. A new survey, similar to that of 1948, of salaries and emoluments paid to Fellows and Associates is to be undertaken, and a new set of

notes on terms of engagement suitable for physicists is being prepared. The appointments register has been discontinued, but notices of vacancies for physicists have been included in the monthly *Bulletin*, and from the steadily increasing demand from employers for such space it would appear that this new procedure is satisfactory.

FIRST NATIONAL POLISH SCIENCE CONGRESS

THE First National Polish Science Congress was held at Warsaw during June 29–July 2, in the magnificent hall of the reconstructed Polytechnic Institute. The Congress was called together to deal chiefly with the reorganization of science in Poland, and the discussions, therefore, concerned administrative problems rather than the details of scientific researches as such. Nevertheless, it was of great importance for Polish science, which lost some 40 per cent of its personnel, and suffered widespread destruction of buildings and equipment in the Second World War. Re-organization was required by the great expansion of facilities and numbers of newly trained scientific workers. It had come to be felt on all hands that a unified National Academy of Sciences was a necessity.

The principal formal business of the Congress consisted, therefore, in the incorporation of the former leading scientific organizations, such as the Cracow Academy of Sciences (Polskie Akademie Umietnosci) and the Scientific Society of Warsaw (Warszawska Towarzystwo Naukowe), both dating from the early years of the nineteenth century, into the new National Academy. The Cracow Academy had always been an honorific and essentially publishing body, while the Warsaw Society, though partly concerned with popularization of science (like the British Association), had come to possess a number of research institutes of its own. The new National Academy, modelled on those of the U.S.S.R., China and other countries, will now possess a network of research institutes, and the academicians will be mainly directors of institutes or departments of institutes.

Preparations for the Congress had involved more than a hundred conferences and meetings covering all branches of science and technology. At these meetings there had been discussion of the best arrangements for the organization of the new institutes. At the Congress itself it was emphasized, in the speech of the president (Dr. Jan Dembowski, zoologist), that during the period of re-organization there would be the minimum interruption of research projects currently under way. But besides these problems, the preliminary meetings had evidently also devoted much time to discussion of theoretical problems in the various sciences—a process no doubt stimulated by the desire of the younger generation of Polish men of science to incorporate the philosophy of dialectical materialism into the background of their thought. The interesting speeches of Dr. Dembowski and of Dr. K. Petruszewicz at the opening plenary sessions were made available to foreign representatives in languages of Western Europe, and it would seem very desirable that they should be published in some way in Great Britain.

Foreign countries were represented by small groups of up to about half a dozen members. The Soviet delegation, headed by Prof. Oparin, the biochemist, was naturally the largest; but there were also delegations from France, Germany, China, Hungary, Sweden, Rumania, etc. From the United Kingdom, Dr. J. Needham brought a message of greetings to the new National Academy from Prof. E. D. Adrian, president of the Royal Society. The foreign representatives were able to listen to the speeches in simultaneous translation, and had the opportunity of meeting a very large number of Polish scientific workers of all generations and all specialities. There can be no doubt that the Congress, and the Academy which it was called upon to found, represent an important step forward in the organization of science in Poland.

J. NEEDHAM

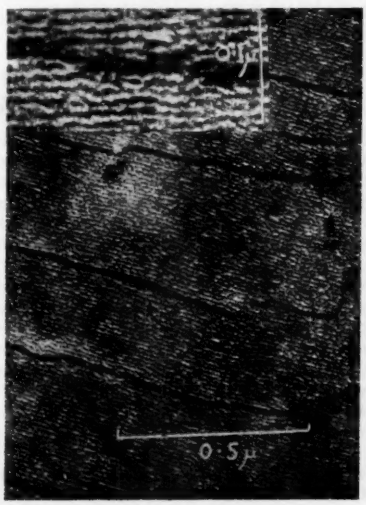
CRYSTAL STRUCTURE OF A LOW MOLECULAR WEIGHT PROTEIN

Electron Microscopy of β-Lactoglobulin Crystals

ELECTRON microscopy of protein crystals has in the past been concerned solely with proteins or nucleoproteins of high molecular weight[1–3]. In this investigation the electron microscope reveals structure in crystals of a protein of a much lower molecular weight, namely, β-lactoglobulin, molecular weight 36,000, which has already been examined by X-ray diffraction methods[4].

Preparations for the electron microscope were made according to the pseudo-replica technique of Wyckoff[3], the specimens being shadow-cast with palladium before stripping from the glass surface. The bulk of lactoglobulin was dissolved out in water before examination of the replica.

The accompanying micrograph is typical of the results. It shows the (100) face. The striations on the crystal face are parallel to the *b*-axis of the crystal. The periodicity is 105 ± 5 A. Molecular steps similar to those shown in earlier published pictures of *n*-hexatriacontane[5,6] occur on the crystal



face. From measurement of shadow-length these steps are found to 50 ± 10 A. in height. The micrograph therefore resolves structure in two crystallographic directions, namely, along *a* and along *c* on the crystal face. It is further evident from the micrograph that the molecules in the crystal are arranged in successive columns parallel to the *b*-axial direction, and this is confirmed by the fact that cross-shadowing does not improve resolution along *b*. It can be seen that the individual columns are in some instances incomplete; the inset enlargement gives two examples of this type of edge dislocation in the crystal lattice.

A direct comparison of the data from X-ray analysis and from electron microscope examination is now possible for the first time for this protein. Since the crystals of β-lactoglobulin were of necessity dried before examination, the results from them can be compared only with the X-ray diffraction results[7] from air-dried preparations. Such results are now given again in the following communication from Dr. D. P. Riley. The periodicity agrees well with previously recorded values for the *c*-axial length[7,8], as does the height of the molecular steps with the *a*-axial value. The concept of molecular packing in columns is supported by the (100) Patterson section given in the accompanying letter.

I wish to thank Prof. J. M. Robertson for his interest and encouragement in this work, the Rockefeller Foundation for an equipment grant to the Department, and Imperial Chemical Industries, Ltd., for a research fellowship. I am grateful to Mrs. D. Hodgkin for the specimen of β-lactoglobulin and for making available to me the X-ray data published in thesis form.

I. M. Dawson

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May 28.

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Structure of Dry β-Lactoglobulin Crystals

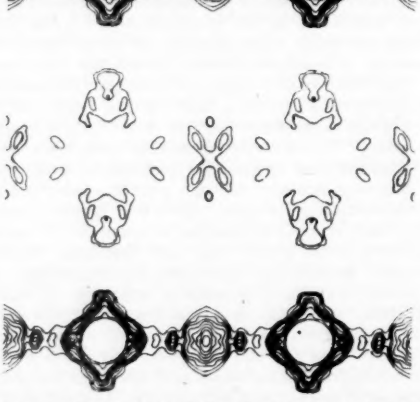
I am encouraged by Dr. Dawson's most interesting communication to present some crystallographic results on β-lactoglobulin which have hitherto only been available in a thesis[1] or in articles[2] mainly of a review character. Attention will be confined to the dry orthorhombic crystals, often described as 'tabular'.

Although I have not examined the actual batch used by Dawson, the habit of his crystals is essentially the same as that of crystals which I have investigated from several other sources and may be written as: tabular {100} elongated along [010]; strongly developed {100} with subsidiary {001} and indefinite {0*kl*}. The crystals show a pseudo-uniaxial interference figure and appear isotropic when viewed along *c* parallel to α.

The unit-cell dimensions of the air-dry crystals are $a = 60$ A., $b = 63$ A., $c = 110$ A. (N.B. The values given in an earlier note[3] are incorrect.) Values in good agreement with these have been reported since by other workers: Fankuchen[4], $a = 60$ A., $b = 62$ A., $c = 111$ A.; Senti and Warner[5], $a = 60{\cdot}7$ A., $b = 61{\cdot}0$ A., $c = 112{\cdot}4$ A. Perfect agreement would not be expected owing to the differences in residual water-content from crystal to crystal.

The relative intensities of 142 *hkl* reflexions have been estimated visually and used to calculate the principal Patterson projections and Patterson–Harker sections. That the structure of the air-dry crystals is not very disordered is demonstrated by the fact that X-ray reflexions occur out to a spacing limit of about 4·5 A. The space group is $P\,2_1\,2_1\,2_1$. The density of the air-dry crystals was measured as $1{\cdot}27 \pm 0{\cdot}01$, but the later figure of McMeekin and Warner[6], $1{\cdot}260 \pm 0{\cdot}003$, is more precise.

Dawson's unit-cell dimensions are $a = 50 \pm 10$ A., *b* undetermined, $c = 105 \pm 5$ A. It is to be expected that these values would be somewhat lower than those given by X-ray measurements on air-dry crystals, as the electron-microscope shadowing technique probably involves further drying in a vacuum chamber. The air-dry crystals still contain[4] 9·78 per cent of water by weight.



Patterson section at $x = O$, $P\,(0, y, z)$, for air-dry lactoglobulin crystals. $b = 63$ A., horizontal; $c = 110$ A., vertical. Higher contours around origin not drawn

The agreement between the electron micrograph and X-ray diffraction evidence is not confined to this near coincidence of unit-cell dimensions. The accompanying figure reproduces the Patterson section at $x = O$, $P\,(0, y, z)$, in which only the higher contours have been drawn, the lowest contour line shown having a value of 10 arbitrary units. For clarity, the very dense region around the origin has been omitted as the contours there rise to a value of 49. This map represents the summation of interatomic vectors lying in the (100) plane and is therefore directly comparable with the electron micrograph. Its main features are the pronounced band of vector density parallel to *b* at $z = 0$ and, conversely, the absence of any very high peaks in the middle of the pattern. This is exactly the Patterson vector-map corresponding to the arrangement of molecules shown in the micrograph, wherein the molecules lie in

columns parallel to b, the columns being separated, centre-to-centre, by the whole c cell-dimension. The Patterson section, however, reflects further structure in the (100) layers which the electron micrograph is unable to resolve. There is, first, the fundamental b-lattice translation. Second, the relatively high peak at $y = \frac{1}{2}$, $z = 0$ shows that the molecules which constitute the columns parallel to b are probably placed with their centres $b/2 = 31{\cdot}5$ A. apart, that is, there is a pseudo-halving of this cell dimension. Third, the two distinctly resolved peaks on the $z = 0$ line, at 10 A. and at $b/2 - 10$ A., indicate the presence of marked intramolecular vectors parallel to b of length 10 A.

On the basis of eight molecules in the unit cell, the anhydrous molecular weight is 35,800, the errors arising particularly from imprecise knowledge of the water-content. Senti and Warner[5] arrive at the more accurate value of 35,400 from consideration of the wet crystals. The volume of the anhydrous molecule, subject to the same errors, is 44,400 A.^{3}, and it can be shown that 85 per cent of the available free volume in the air-dry crystal is occupied by water.

Reliable knowledge of the shape of the molecule with its actual linear dimensions is now clearly very near and should result from a re-examination of the X-ray data in conjunction with further electron micrographs.

D. P. Riley

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July 3.

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SMITHSONIAN INSTITUTION

ANNUAL REPORT FOR 1949–50

THE report of the Secretary of the Smithsonian Institution for the year ended June 30, 1950*, points out that increasing pressures on all sides and definite trends in certain countries towards the regimentation of science enhance the importance of the freedom of inquiry which the Institution has always sought to further, and it records that government support of the ten branches of the Institution has not kept pace with modern exigencies, particularly in physical plant and facilities.

Reference is again made to congestion at the National Museum and at the Natural History and the Arts and Industries Building. The task of modernizing exhibits in the museums, which were visited by more than 2,600,000 persons during the year, is now proceeding as rapidly as funds become available for the purpose. The collections at the National Museum were increased by about 793,300 specimens during the year, while, in the field, investigations of the bird life of northern Colombia and of eastern Panama continued. Natural history collections were made on Prince Patrick Island in the Canadian Arctic archipelago, and other work has included a short field study of molluscs inhabiting the salt marshes on the eastern shore of Maryland, botanical field studies on Big Pine Key, Florida, extensive collections of lichens under the auspices of the Arctic Institute of North America, and a study of the origin and occurrence of rare sulphate minerals at the Geysers and Island Mountain, California; four field parties studied problems in invertebrate palæontology.

The Director of the Bureau of American Ethnology continued his studies of archæological collections made in Panama, and the survey work of the Bureau for the year has covered twenty-six reservoirs situated in eight States and five river basins. At the end of the year, excavations were completed or under way in thirteen reservoir areas in nine States, and, since the start of this River Basin Survey in July 1946, 120 reports have been issued, the investigations being conducted in co-operation with the National Park Service, the Bureau of Reclamation of the Department of the Interior, the Corps of Engineers and other non-government institutions. Archæological investigations conducted on Cornwallis Island in the Canadian Arctic have yielded a large collection of artefacts which have thrown considerable light on the prehistoric inhabitants of the region; further studies were made of the Iroquois, especially at the Tonawanda and Alleghany Seneca reservations in western New York, and Dr. J. P. Harrington continued his study of the grammar of the Abnaki language at Old Town, Maine. The Institute of Social Anthropology continued its anthropological teaching and research programmes in Brazil, Colombia, Mexico and Peru, and issued during the year Vol. 5 of the "Handbook of South American Indians".

The International Exchange Service handled 1,009,675 packages of government, literary and scientific publications, an increase of about twenty per cent, and the majority of the publications now being transmitted are current issues. Consignments are now made to all countries except Rumania and China, and ninety-nine sets of United States official publications are now sent abroad in exchange for similar publications of other countries, fifty-nine of these being full sets. A list of depositories of the sets is given in the report. The value of the National Zoological Park has been enhanced by addition of a number of animals never before exhibited there, and research has continued to be an important feature of its operations. At the Astrophysical Observatory the Division of Radiation and Organisms completed its reorganization and reconstruction of its laboratories; and the Division of Astrophysical Research, besides constructing three silver-disk pyrheliometers for institutions in New Zealand, Venezuela and Rumania, and two modified Angström pyrheliometers and a special water-vapour spectroscope for a meteorological institute in Belgium, has calculated that there has been an increase of 0·25 per cent in the radiation emitted by the sun in the two decades 1925–44 from solar-constant determinations at the Chilean station.

Twenty-one scientific workers visited Barro-Colorado Island in the Canal Zone Biological Area during the year and worked at various research projects. The Smithsonian Library received 53,035 publications during the year and currently enters 16,961 periodicals, mostly in exchange for its own publications. With the Secretary's report is included the financial report of the executive committee of the Board of Regents.

* Report of the Secretary of the Smithsonian Institution and Financial Report of the Executive Committee of the Board of Regents for the Year ended June 30, 1950. (Publication 4020.) Pp. ix+161. (Washington, D.C.: Govt. Printing Office, 1950.) 50 cents.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Origin of the Word 'Protein'

In an address to the Swedish Royal Academy of Sciences on "The Place of Berzelius in the History of Chemistry" and in the Berzelius Memorial Lecture to the Royal Society, I claimed for Berzelius the authorship of the word 'protein'. This claim was based on the following passages in a letter to Mulder, the Dutch chemist, dated July 10, 1838:

"Or je présume que l'oxyde organique, qui est la base de la fibrine et de l'albumine (et auquel il faut donner un nom particulier p. ex. protéine) est composé d'un radical ternaire, combiné avec de l'oxygène dans quelqu'un de ses rapports simples que la nature inorganique nous présente."

And later in the same letter:

"Le nom protéine que je vous propose pour l'oxyde organique de la fibrine et de l'albumine, je voulais le dériver de πρωτειος parce qu'il paraît être la substance primitive ou principale de la nutrition animale que les plantes préparent pour les herbivores et que ceux-ci fournissent ensuite aux carnassiers."

Prof. A. C. Chibnall then pointed out to me that the credit for coining the word 'protein' was generally given to Mulder, and that the "Oxford English Dictionary" gives a reference to the first use of the word in his paper "Sur la composition des quelques substance animales" in the monthly issue of the *Bulletin des Sciences physiques et naturelles en Néerlande* dated July 30, 1838. The word 'protein' first occurs in print in this paper in the following sentence:

"La matière organique, étant un principe général de toutes les parties constituantes du corps animal, et se trouvant comme nous verrons tantôt, dans le règne végétal, pourrait se nommer Protéine de πρωτειος primarius."

The parallelism between these passages seemed to me too close to be an accidental coincidence; but a study of the Berzelius–Mulder correspondence edited by the late Dr. Söderbaum and published by the Swedish Royal Academy of Sciences brought to light no previous mention of the word 'protein' by either of them. Dr. Arne Holmberg, librarian of the Academy, then very kindly examined the post-marks on the Berzelius letter of July 10, 1838, which showed that it reached Greifswald on July 14, and although the post-mark at Rotterdam is illegible, the evidence of the transit time of another letter makes it probable that it reached Mulder by July 20. Mulder's paper opens with a generous acknowledgment of his debt to Berzelius, and there seems to me little doubt that he adopted Berzelius's suggestion without making any specific acknowledgment to him.

Prof. H. B. Vickery, in a paper on "The Origin of the Word Protein" in the *Yale Journal of Biology and Medicine* (22, No. 5; May 1950), examines the evidence in great detail and agrees with this view.

Thus, we owe to Berzelius in his later years not only the generalizations which he crystallized in the words 'isomerism', 'polymerism' and 'catalysis', but also the word 'protein' which he coined to express the fundamental significance of certain substances in nutrition, the sense in which we still use it to-day.

Harold Hartley

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Observations of the Golgi Substance with the Electron Microscope

Observations by several investigators during the past few years lend support to the view that the Golgi substance is present in living cells in the form of droplets stainable supra-vitally with certain vital dyes[1–4]. The classical form of the Golgi substance has been considered to be a gross artefact induced by the development of myelin figures from droplets of phospholipid[3,4]. This view has been accepted by some[5–7] and questioned by others[8,9]. It was felt that observations with the electron microscope might aid in the elucidation of this complex problem. With this possibility in mind, liver and intestinal epithelium were fixed by perfusion in two different fixatives, one the Kolatchev–Nassonov modification of Champy's fluid[10] and the other a mixture of equal parts of 2 per cent osmic acid, 3 per cent potassium dichromate and 2 per cent lanthanum nitrate. The *p*H of the former fixative is 2·0 and that of the latter is 3·4. After fixation, slices of tissue were transferred to the same fixative for varying lengths of time. Both tissues were examined during the period of fixation with oil immersion at a thousand diameters by crushing the tissues under a coverslip in water or glycerine. Neither myelin figures nor the Golgi substance could be identified during the first twenty-four hours with the osmic acid, potassium dichromate, lanthanum nitrate mixture, nor during the first forty-eight hours fixation with modified Champy's fluid. Further treatment with 2 per cent osmic acid for three days at 37° C. resulted in the appearance of the Golgi substance with its typical form and distribution throughout both tissues after fixation in modified Champy's fluid but not after fixation in the osmic, dichromate, lanthanum mixture. Secondary treatment of the tissues preserved in the latter fixative with a mixture of equal parts of 3 per cent potassium dichromate and 1 per cent chromic acid followed by treatment with 2 per cent osmic acid for four days at 37° C. resulted in the development of faint positive images of the Golgi substance, whereas secondary treatment with modified Champy's fluid for twenty-four hours followed by treatment with 2 per cent osmic acid at 37° C. for four days resulted in the development of typical, well-blackened Golgi figures in both tissues.

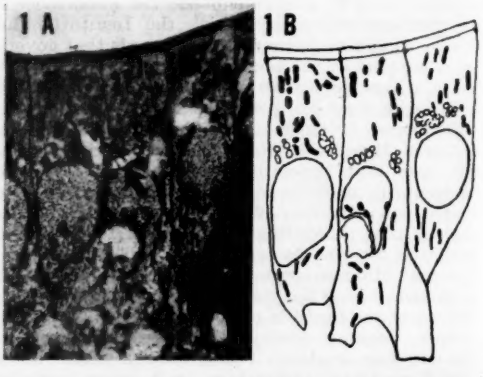

Fig. 1*A*. Electron micrograph of a principal cell of the duodenum fixed for twenty-four hours in modified Champy's fluid, showing empty vacuoles, arrow (osmiophobic component of the Golgi substance), in the Golgi zone (× 2,000 approx.). *B*. Tracing of the cell in Fig. 1*A*, to emphasize the vacuoles: mitochondria black

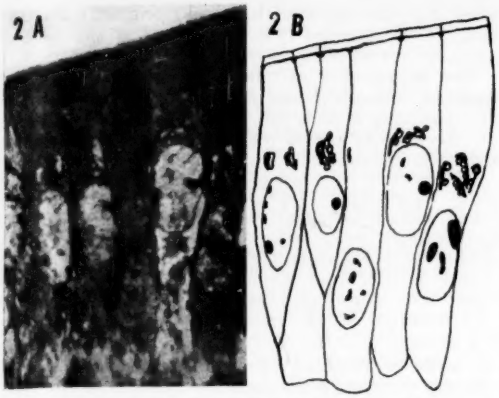

Fig. 2*A*. Electron micrograph of a principal cell of the duodenum fixed for twenty-four hours in modified Champy's fluid followed by treatment with 2 per cent osmic acid at 37° C. for three days, showing vacuoles comparable to those seen in Fig. 1 associated with osmiophilic material, arrow (osmiophilic component), in the surrounding cytoplasm (× 2,000 approx.). *B*. Tracing of the cell in Fig. 2*A* to emphasize the vacuoles and osmiophilic material

Examination of these tissues under the electron microscope disclosed the presence of negative images of the Golgi substance in principal cells of the intestine (Fig. 1) but not in hepatic cells after preliminary fixation in both fixatives. These negative images consisted of rows and groups of vacuoles, some showing slight darkening with osmic acid, others being completely empty. After treatment with osmic acid, positive images were found to consist of areas of blackened cytoplasm in juxtaposition to the vacuoles (Fig. 2). Few vacuoles were found in association with the Golgi substance in hepatic cells (Fig. 3).

Thus the Golgi substance is considered to consist of an osmiophilic and an osmiophobic component in principal cells of the intestine of the mouse, but frequently of an osmiophilic component only in hepatic cells. The osmiophilic component is believed to consist of a substance in the cytoplasm of the Golgi zone which reduces osmic acid only after treatment with a combination of strong oxidizing agents such as chromic acid, potassium dichromate and osmic acid. This characteristic distinguishes it from other substances in the cytoplasm which react directly and more readily with osmic acid.

These results suggest that the 'flexuose tubules' described by Gatenby in the hepatic cell of the rat[8] are not present in the hepatic cell of the mouse and that the osmiophilic component of the Golgi substance is not involved in myelin figure formation in the sense of Palade and Claude[3,4]. They also indicate that Baker's suggestion[5] of substituting the term 'lipochondria' for the term 'Golgi apparatus' because of the undesirability of continuing "to apply the name of the great Italian neurologist to an artefact" was possibly premature.

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June 12.

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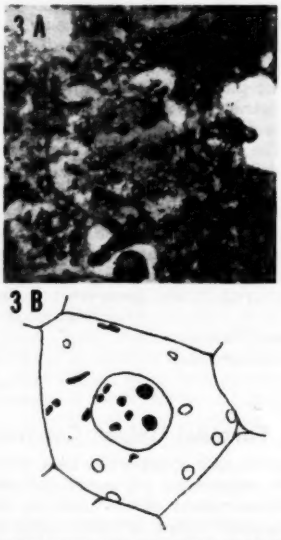

Fig. 3*A*. Electron micrograph of a hepatic cell fixed in modified Champy's fluid followed with treatment with 2 per cent osmic acid at 37° C. for three days, showing the osmiophilic component of the Golgi substance only, arrow (× 2,000 approx.). *B*. Tracing of the cell in Fig. 3*A* to emphasize the osmiophilic component of the Golgi substance. Osmiophilic spheroids (lipoid ?) in cytoplasm in outline form

Superconductivity of Lead Isotopes

Before the discovery of the isotope effect in the superconductivity of mercury[1,2], it was generally assumed that the variation in the atomic weight (M) of a substance would not influence its transition temperature (T_c). This assumption was based on measurements by Onnes and Tuyn[3], and Justi[4], who had compared the transition temperatures of uranium lead and ordinary lead, and had found them to be identical. Observations of isotope shifts in the transition temperature of tin[5–7], and their agreement with the general theory of Fröhlich[8], make it probable that such an effect should also exist in lead. Assuming the validity of Fröhlich's formula $T_c \propto 1/M^{1/2}$, the isotope shift in lead would be of the order of 0·025° K. This difference will have just escaped notice with the resolution used by Onnes and Tuyn, but could have been observed by Justi, who claimed an accuracy of temperature measurements to within several 1/1,000° K.

Measurements of the transition temperature have now been carried out on two lead samples with mean atomic weight of 206·15 and 207·72. The method[9] used was identical with that previously employed in this Laboratory, except that the gas thermometer readings were supplemented by a resistance thermometer. The disappearance of the electrical resistance of the two samples was found to be sharp to within 0·002° K., indicating good chemical purity of the metal. The transition temperature of lead-206·15 was found to be $0{\cdot}038_6 \pm 0{\cdot}002°$ K.

higher than that of lead-207·72. No attempt has as yet been made to determine with great accuracy the absolute value of the transition points, which are slightly above 7·2° K. The resulting power of $M(0{\cdot}73 \pm 0{\cdot}05)$ thus appears to be somewhat higher in our experiments than that predicted by Fröhlich (0·5).

Lead-207·72 (extracted from Ceylon thorite)[10] was kindly lent to us by Prof. F. Soddy, and spectrographically analysed by Mr. G. H. Palmer, of the Atomic Energy Research Establishment, Harwell.

We are grateful to Mr. C. H. Collie for lending us the uranium lead sample (lead-206·15) which was obtained from the Eldorado Mining Company of Canada. I wish to thank Dr. K. Mendelssohn for his interest and advice, and my husband, J. L. Olsen, for his help with the experiments.

Marianne Olsen

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Oxford.
June 5.

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The Clock Paradox in Relativity Theory

The clock paradox discussed by Prof. McCrea in his letter in *Nature* of April 28 is, as he says, no paradox at all. It exists only for observers who have been asleep during the changes of direction of motion of the clocks.

A stumbling-block to handling the problem by using the Lorentz transformations is that these apply only to uniform motion, not to a clock reversing its direction of travel. This difficulty may be avoided if we make use of auxiliary moving clocks, to which the epochs of the original clocks are communicated as they pass each other.

Consider two identical railway trains in uniform motion at different rates; call them A and B. Observers on these trains make indistinguishable observations of uniform separation or approach. For convenience, locate our co-ordinate system on A, that is, consider it stationary. At some point in the progress of B let another identical (auxiliary) train C pass it going in the opposite direction at such a rate that it ultimately passes A. Let the epoch on the clock on B be flashed to a clock on C as they pass. Then as C passes A (B meanwhile passing off into space), a comparison of the epochs of the clocks on A and C shows the clock on C—since B and C have both been in motion with respect to A—to be behind the clock on A. The observer on A sees a clock pass him in one direction, and if he has not seen the transfer operation, sees the clock returning, having lost time in the process.

For an observer on B the similar experience is presented, when at some point A is passed by a train D travelling at such a speed that it ultimately overtakes B. It reaches B by *travelling at a higher velocity* than B; the epoch of its clock, originally flashed from A, is retarded over B because of this higher velocity in travelling over the same distance.

The argument is as follows: Designate by L the distance between A and B when D catches up with B. The time is then L/v, where v is the velocity of B. Because of the slowing down of B's clock, this time will be read:

$$t'_B = \frac{L}{v}\sqrt{1 - \frac{v^2}{C^2}} \cong \frac{L}{v} - \frac{1}{2}\frac{Lv}{C^2}.$$

Now D traverses the distance L in time L/V, where V is D's velocity. This will be read by D's clock as:

$$t'_D = \frac{L}{V}\sqrt{1 - \frac{V^2}{C^2}} \cong \frac{L}{V} - \frac{1}{2}\frac{LV}{C^2}.$$

D, however, received its epoch from A when B had already travelled some distance l, that is at the time l/v, so that the time read on D will be:

$$T'_D = t'_D + \frac{l}{v}.$$

Now $\dfrac{L - l}{v} = \dfrac{L}{V}$, or $\dfrac{l}{v} = \dfrac{L}{v} - \dfrac{L}{V}$;

so that we have:

$$T'_D = t'_D + \frac{l}{v} = \frac{L}{V} - \frac{1}{2}\frac{LV}{C^2} + \left(\frac{L}{v} - \frac{L}{V}\right)$$
$$= \frac{L}{v} - \frac{1}{2}\frac{LV}{C^2};$$

which is to be compared with t'_B above. Since V is greater than v, the time by D's clock is less than the time by B's clock.

Thus, B also observes a clock moving away from him, and later (not having observed the process of transferring epoch from A to D) sees 'the clock' returning, having lost time. Both observers conclude that it is the other's clock that has slowed down.

If in the first case an observer on B is (in a state of unconsciousness) trans-shipped from B to C at the same time that the interchange of clock readings is made, when he awakes he observes A approaching him. When he passes A he finds *his* clock is behind A's clock, contrary to his expectation that since A has receded and approached it will be A's clock that has lost. He thus discovers that he has been 'Shanghaied' while unconscious. The observer on A, as described above, similarly unconscious while the B—C transfer occurs, agrees with the B—C observer, when they meet, that the latter's clock has lost time—there is no clock paradox. The observer on A is also reassured, if he has followed this argument, that he has stayed on the same train during his nap.

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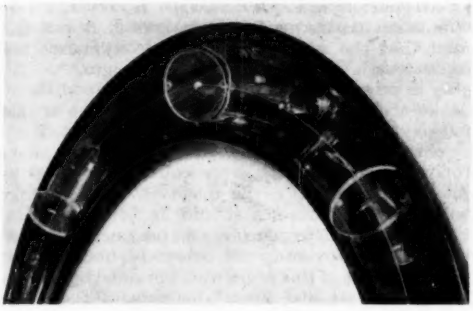
A Toroidal Geiger Counter

A toroidal Geiger counter has been constructed in an attempt to produce a γ-ray sensitivity detector with a response independent of the position of the γ-ray source over a small region of space. The counter was made from two U-shaped half-sections (radius ½ in.), one of which is shown in the photograph, pressed from 24 S.W.G. oxygen-free copper. The counter was designed in the first instance for experiments in which it was necessary to pass the counter freely

over the human head, and for this reason a toroid of mean diameter 12 in. was made. The centre wire, of 0·008-in. diameter tungsten, was supported by eight equi-spaced 'Perspex' disks with central holes through which the wire was a push-fit. These insulators were keyed to one half-section of the counter by phosphor-bronze spigots which projected $\frac{1}{8}$ in. into the edges of the disks. The connexion to the centre wire was taken out through a metal-to-glass seal of commercial pattern, and the two halves of the counter were soldered together using solder-paste and 60/40 soft solder. No difficulty was found in making a vacuum-tight joint without excessive penetration of flux into the tube. A connexion to the vacuum system was made via a lead alloy stem, and the tubes were pumped and filled with a mixture of 10 per cent ethyl alcohol and 90 per cent argon to a pressure of 10 cm. mercury in the usual manner.



Half-section of a toroidal counter showing the lead-out insulator and the 'Perspex' disks supporting the centre wire

A typical counter has an operating threshold of 1,100 volts and a plateau of about 200 volts with a maximum slope of 0·06 per cent volt^{-1}. Unshielded, the background is about 1,000 counts min.$^{-1}$, which appears rather high considering the effective length of the counter; it may be that discharge effects over the 'Perspex' insulators contribute to the background count. In the plane of the counter, the counting-rate due to a small 1-μgm. γ-ray source of radium at the centre of the toroid is 2,500 min.$^{-1}$, which does not change more than ± 10 per cent from the mean for movements within a concentric circle of radius 8 cm. Outside this region the counting-rate increases, especially rapidly as the source approaches the counter wall. With a point source on the central axis at right-angles to the plane of the ring, the counting-rate does not change more than 5 per cent over distances of ± 5 cm. from the plane of the ring.

One interesting property of this counter is its response to γ-rays from the same amounts of radioactive salt dissolved in different quantities of solvents. For example, with 25 μc. quantities of radioiodine in volumes of water of 50–1,000 c.c. filling spherical flasks placed concentric with the counter, the counting-rate was the same (~ 10,000 counts min.$^{-1}$) within 2 per cent in all cases. This result may be fortuitous, arising from the particular size of the counter which has been made; but it does suggest a simple apparatus for assessing the excretion of radioiodine in thyroid function analyses without making volumetric measurements.

Further details of the counter will be published later. At present, to find under what conditions a uniform sensitivity over a greater volume of space can be obtained, experiments are proceeding with two similar toroidal counters arranged in a system analogous to a Helmholtz coil.

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Dielectric Behaviour of Human Blood at Microwave Frequencies

In the course of studies of microwave absorption in human tissues, measurements have been made of the dielectric constant, $\varepsilon' - j\varepsilon''$, of whole human blood at a number of frequencies in the range $1{\cdot}78 \times 10^9$ c./s. to $2{\cdot}36 \times 10^{10}$ c./s., employing co-axial-line and wave-guide methods described elsewhere[1,2]. The specimens used had red cell concentrations within the limits $4{\cdot}9 \pm 0{\cdot}1 \times 10^6$ cells per mm.^{3} and were heparinized to prevent coagulation.

Dispersion was found to occur and the experimental results to agree, within experimental error (± 2 per cent in ε' and ± 5 per cent in ε''), with values calculated from the Debye equations with a single relaxation time, τ, if dielectric loss due to an ionic conductivity, σ_i, was allowed for. The values of ε^* (the value from which ε' falls in the dispersion region), ε_∞ (the value ε' asymptotically approaches at high frequencies), τ and σ_i which have been derived from the analysis of the results at three temperatures are shown in the accompanying table, together with corresponding values of ε^* and σ_i for blood plasma.

The dispersion observed can be attributed entirely to dipolar orientation of part of the water present in blood. The dispersion effects of inhomogeneity, investigated previously by others (see, for example, Danzer[3] and Schwan[4]), appear to be absent at microwave frequencies. The relaxation times shown in the table are approximately 8 per cent higher than the values for pure water at the same temperatures. Recent work[1] indicates that this increase is probably related to hydrogen-bond formation between water molecules and active groups of other molecules.

Temp. (° C.)	Whole blood				Blood plasma	
	ε^*	ε_∞	τ	σ_i ohm^{-1} cm.$^{-1}$	ε^* (calc.)	σ_i ohm^{-1} cm.$^{-1}$ (exp.)
15	62·0	4·5	$1{\cdot}19 \times 10^{-11}$ sec.	0·010	78·3	0·0108
25	58·0	4·5	0·90 ,, ,,	0·012	74·3	0·0128
35	56·0	4·5	0·70 ,, ,,	0·014	70·6	0·0155

Further analysis of ε^* and σ_i for whole blood and plasma has been carried out by application of theories for inhomogeneous dielectrics. Those of Maxwell[5], Wiener[6] and Fricke[7] all lead to the relation

$$\frac{k - k_1}{k + xk_1} = \rho \frac{k_2 - k_1}{k_2 + xk_1},$$

when k, k_1 and k_2 are the dielectric constants or specific conductivities of the suspension, the suspending and the suspended media respectively, ρ is the volume concentration of the suspended medium and x is a numerical factor depending on the shape of the suspended particles and on the ratio k_2/k_1. Fricke[8] has shown the theory to hold in the cases of the low-frequency conductivity of blood and of cream

up to a concentration of 62 per cent of cream in skimmed milk. It will be assumed that the theory also holds in the present case and that the effect of cell-membrane impedance is negligible at microwave frequencies.

Using the values of ε^* and the corresponding dielectric constants of blood plasma given in the table, and assuming the effect of cells other than erythrocytes is negligible, the above relation gives the dielectric constant of the contents of the red cell as 43·9, 40·1 and 39·8 at 15°, 25° and 35° C. respectively. Further, assuming the relation also applies to the cell contents and that a hæmoglobin molecule with its hydration sheath is an oblate spheroid of axial ratio 2, further use of the above equation gives the volume and hydration of the cell hæmoglobin. The mean value for hydration found from the results at the three temperatures is $0{\cdot}23 \pm 0{\cdot}16$ gm. water per gm. hæmoglobin. This is in fair agreement with the estimate derived by Haggis *et al.*[9] from microwave measurements on hæmoglobin solutions.

It is of interest to note that if the hydration is calculated by use of a simple volume proportion relation[10,11] for the dielectric constant of the cell contents, the estimate obtained is twice the figure quoted above.

In the case of ionic conductivity, application of the above law for inhomogeneous media using the conductivities given in the table shows that the ionic conductivity of the intracellular fluid is 83 per cent of that of the plasma. This is in good agreement with published data[12] for the ion balance of normal human erythrocytes and plasma, from which a ratio of 0·79 is obtained.

Full details of this work, and of corresponding microwave studies on human tissues, will be published elsewhere.

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Relation between Polyploidy and the Amounts of Deoxynucleic Acid per Nucleus in the Liver and Kidney of Adult Rats

The nuclei of the livers of rats vary greatly in size, and it was found[1,2] that the nuclear volumes formed a geometric series of type 1, 2, 4. Beams and King[3] showed that the doubling of the nuclear volumes was due to polyploidy, so that within the cells of the liver there were nuclei which contained the diploid, tetraploid or octoploid number of chromosomes. In the liver of the adult rat, 70–80 per cent of the nuclei were tetraploid, and almost all the nuclei in the remaining 20–30 per cent were diploid with only a few per cent octoploid[1,2]. Mirsky and Ris[4] demonstrated that in tissues the deoxynucleic acid was situated in the chromosomes, and it was suggested that the amount of deoxynucleic acid per nucleus was related to the chromosome number. Therefore, a large proportion of the nuclei in the liver of the adult rat should contain twice the amount of deoxynucleic acid found in the diploid nucleus. No direct evidence has been obtained for the rat; but Swift[5] has shown in the adult mouse, by using the absorption of Feulgen-stained nuclei in histological sections as a measure of the amount of deoxynucleic acid per nucleus, that most of the nuclei in the liver contained twice the common amount of deoxynucleic acid which had been found in the small liver nuclei and in the nuclei of other tissues, including the kidney.

From the analyses of suspensions of nuclei it is only possible to obtain a mean value for the amount of deoxynucleic acid per nucleus. However, for the mammalian tissues so far investigated, it has been found that the mean amount of deoxynucleic acid per nucleus is always about 6×10^{-6} μgm.[6–8]. This value is presumably equal to the amount of deoxynucleic acid in the diploid nucleus. If the amount of deoxynucleic acid per nucleus is associated with the chromosome number, it should follow by simple proportion that, in the liver containing 70–80 per cent tetraploid nuclei, the mean amount of deoxynucleic acid per nucleus should lie between 10 and 11×10^{-6} μgm. deoxynucleic acid per nucleus (assuming that the percentage of octoploid nuclei is negligible). Values of this order were obtained by Dounce, Tishoff, Barnett and Freer[9] for rats of the Wistar strain. Further, it has recently been found that the mean amounts of deoxynucleic acid per nucleus in the livers of three male and three female black-and-white hooded rats, of mean weight 270 gm. and 205 gm., were $9{\cdot}6$ and $10{\cdot}2 \times 10^{-6}$ μgm. respectively. It is proposed to report these findings in more detail elsewhere.

In order to determine whether a relationship does exist between the amount of deoxynucleic acid and the number of chromosomes in the nucleus, it was decided to estimate in the same animals the mean amounts of deoxynucleic acid per nucleus in the kidney as well as in the liver, since the former tissue contains only nuclei with the diploid number of chromosomes. The livers and kidneys were removed from seven adult female black-and-white hooded rats of the Lister strain and of mean weight 200 gm. The samples of liver and of kidney cortex were each separately pooled for analysis. The nuclear suspensions were prepared by the method of Dounce[10] in an aqueous citric acid medium at *p*H 4. The deoxynucleic acid was estimated as deoxynucleic acid phosphorus after removing the acid-soluble, phospholipid and ribonucleic acid fractions[11]. The nuclei in the suspension were counted in a hæmacytometer, and from these results the mean amount of deoxynucleic acid per nucleus was deduced.

In the liver the mean amount of deoxynucleic acid was $10{\cdot}1 \times 10^{-6}$ μgm. per nucleus, whereas the mean amount in the kidney was $5{\cdot}7 \times 10^{-6}$ μgm. deoxynucleic acid per nucleus. The value for the kidney is in close agreement with that reported for the diploid nuclei. From these values for the liver and the kidney it may be calculated, assuming as before that the percentage of octoploid nuclei is negligible, that about 76 per cent of the nuclei contained the tetraploid number of chromo-

somes. This result agrees very closely with that observed histologically by Sulkin[1] and McKellar[2].

From the results it may be concluded that the high values which have been obtained for the mean amount of deoxynucleic acid per nucleus in the liver of the rat have been due to the presence of nuclei containing the tetraploid and octoploid number of chromosomes. The striking agreement between the values for the degree of polyploidy obtained by histological measurements and by calculation from chemical analyses suggests that a doubling in the number of chromosomes is accompanied by a doubling in the amount of deoxynucleic acid per nucleus. Therefore, it would appear that for the rat there is a direct relationship between the amount of deoxynucleic acid per nucleus and the number of chromosomes. The significance of these findings in the calculation of the mass of the liver cell will be discussed in a later paper.

I am indebted to the International Federation of University Women for the award of the Alice Hamilton International Fellowship.

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Coenzyme of Kidney Phosphatase

It has been deduced from dialysis at different *p*H that kidney phosphatase can be separated according to the scheme :

holophosphatase ⇌ cophosphatase + apophosphatase[1].

By mixing the dialysis liquid with the solution of inactivated phosphatase and adding magnesium, reactivations up to 100 per cent can be reached : by adding to the apoenzyme boiling solutions of the enzyme, in which the coenzyme remains unaltered, partial reactivations can also be obtained. Albers thinks that the coenzyme cannot be magnesium, but a labile organic substance which has not been identified.

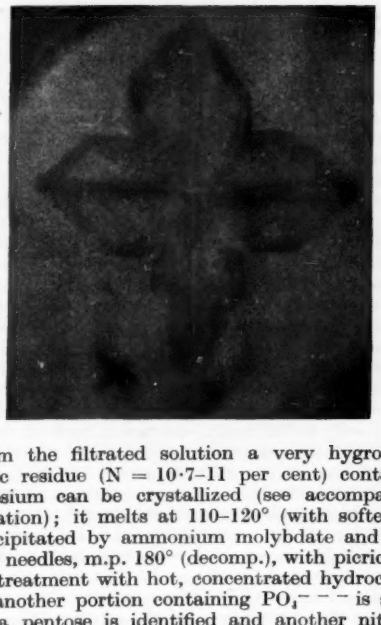
These results have been ascribed alternatively to the presence of small amounts of zinc or cobalt ions, which are able to form a dissociable complex[2]. On the same lines, kidney phosphatase has been considered as an enzyme with dissociable metal (magnesium and also zinc) which may not contain a dissociable coenzyme ; so the enzymatic activity would be connected with co-ordination in a metal complex of various fragments of the apoenzyme[3].

It has also been suggested that the dialysable prosthetic group could be a combination of a metal and a substance containing amino-acids ; this has been inferred from experiments of reactivation of phosphatase with amino-acids in the presence of metallic ions[4]. But the active entity of boiled solutions cannot be replaced by amino-acids, according to another series of experiments[5].

Following our research on organic models of phosphatase[6] and in order to get a better knowledge of the composition of the enzyme, we have carried out experiments on the dialysis of kidney phosphatase. This was obtained by the Albers method, and we have verified previous results on inactivation, going further in the study of the dialysed liquid.

The liquid of acid dialysis, on evaporation *in vacuo*, gives a residue having 5·2 per cent nitrogen. The spectral analysis of the ash gives magnesium, zinc, nickel, calcium, iron, sodium and potassium—the same metals present in the phosphatase before dialysis[7], but which are not contained in the apoenzyme.

The same residue, treated with alcohol, deposits the mineral part—an insoluble white solid containing the metals referred to before, except magnesium. It also contains phosphorus (24·1 per cent of phosphate) corresponding to a formula PO_4HM^{II} with an average atomic weight of 30 for M^{II}.



From the filtrated solution a very hygroscopic organic residue (N = 10·7–11 per cent) containing magnesium can be crystallized (see accompanying illustration) ; it melts at 110–120° (with softening), is precipitated by ammonium molybdate and gives yellow needles, m.p. 180° (decomp.), with picric acid.

By treatment with hot, concentrated hydrochloric acid, another portion containing PO_4^{---} is separated, a pentose is identified and another nitrogen compound (N = 23·5 per cent), which is not precipitated with ammonium molybdate and picric acid, is isolated. The spectrum of this substance is now under study.

The results so far obtained suggest that kidney cophosphatase is a metallic derivative of a diphosphonucleoside, probably derived from adenosine, as can be deduced from analytical data and spectral analysis.

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Adrenotropic Hormone (ACTH), Aminopterin and Eosinophil Count

Recent experiments indicate that a relationship might exist between aminopterin and adrenal cortex function. Dougherty and Dougherty[1] report that, following adrenalectomy, mice do not show the lymphopænia and acute atrophy of lymphatic tissue which are observed following a lethal dose of aminopterin. Higgins[2], using aminopterin and aminoteropterin, showed that adrenalectomy minimized considerably the changes induced by such drugs within the spleen, the thymus gland, the peripheral blood and bone marrow of rats. They assumed that some effects of aminopterin can be due to a stimulation of the adrenal cortex. On the other hand, Hanlon[3] of the Mayo Clinic has observed that aminopterin in human subjects gives a rather marked decrease in the output of corticosteroids and, in no case, an increase.

In our experiments we first attempted to see whether administration of adrenotropic hormone (ACTH) (kindly supplied by Irby Bunding, of the Biochemical Department, Armour and Company, Chicago, Illinois) would influence the survival time of mice injected with 50 mgm. per kgm. of aminopterin (kindly supplied by Dr. J. M. Ruegsegger, of the Lederle Laboratories Division, American Cyanamid Company, Pearl River, New York).

Twelve albino mice (mean weight 20 gm.) were divided into two groups. Each mouse of the first group was injected with 1 mgm. of aminopterin intraperitoneally and these were used as controls. The mice of the second group received 1 mgm. of aminopterin intraperitoneally and 2 mgm. of ACTH intramuscularly, divided in two doses. The ACTH was then given to them in the same dosage every day until death occurred. All the animals of both groups died within the fourth day after the injection of aminopterin. No appreciable difference was detected in the time of survival between the animals not treated with ACTH and those which received 2 mgm. of ACTH daily. In other words, in our experiments a stimulation of the adrenal cortex by ACTH does not affect the toxicity of aminopterin, although an absence of its function has been stated to minimize the effects of the aminopterin and teropterin.

Another point we tried to establish was whether aminopterin could interfere with the response of the adrenal cortex to ACTH. The response of the adrenal cortex to the stimulation by the adrenocorticotropic hormone was tested by means of an eosinophil count. The eosinophils were stained by Pilot's method[4].

Experiments were performed on eight guinea pigs (mean weight 500 gm.). On each of the animals an eosinophil count was done. The following values were obtained: 116, 84, 90, 45, 160, 35, 214, 180. Then 1 mgm. of ACTH was given to each animal, and after four hours another eosinophil count gave the following results: 45, 50, 35, 10, 40, 0, 60, 70. In other words, all the animals showed a drop of eosinophils which was about one-half or more of the initial count.

Then each guinea pig received one mgm. of aminopterin intraperitoneally every day for five days. On the fifth day another eosinophil count was made on them and the following values were obtained: 45, 32, 64, 0, 700, 40, 0, 400, 27. (The two guinea pigs which showed an increased eosinophil count were found at necroscopy to be pregnant at a very early stage.) Then 1 mgm. of ACTH was given to each animal, and after four hours a new eosinophil count was made. The results were respectively: 10, 0, 3, 0, 120, 0, 0, 85, 0. In other words, the animals treated with aminopterin showed a normal response (so far as it can be determined through the eosinophil count method) of the adrenal cortex to ACTH. Since the decrease of eosinophils following ACTH in animals treated with aminopterin has been more marked than in the control animals, it might be assumed that the response to ACTH is increased in animals treated previously with aminopterin. This would concur with the findings of adrenal cortex hypertrophy in animals treated with aminopterin. On the other hand, it is difficult for us to explain the observation by Hanlon[3] of a decreased output of corticosteroids in patients treated with aminopterin, unless it might be caused by the difference in the dose of aminopterin.

I am grateful to Mr. Maurice Szafarowicz for technical assistance.

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Histochemical Evidence of the Presence of Acid-Phosphatase-Positive and -Negative Cell Islets in the Adrenal Medulla of the Rat

Recent investigations have demonstrated the presence of *nor*adrenaline as well as adrenaline in the adrenal medulla of some mammals. In this communication, histochemical observations are reported indicating the presence of two different kinds of cell islets in the adrenal medulla of the rat.

The material consisted of about fifty adrenals of healthy rats. For the demonstration of acid phosphatase an improved technique[1] modified from Gomori's[2] procedure was used. This technique always gave reproducible results free of the capricious variations frequently characterizing the original method.

The greater part of the adrenal medulla contained large amounts of histochemically demonstrable acid phosphatase, already evident after immersion for 10 min. in the substrate solution. Another part, on the contrary, was still pale in sections treated for two hours in the substrate. The accompanying

Camera lucida drawing showing the distribution of acid-phosphatase-positive materials in the adrenal medulla of a male rat

camera lucida drawing shows the distribution of phosphatase-positive and -negative substances, the former shown as black. In preparations stained by the ordinary histological methods, these tissues did not differ from each other and both of them were composed of typical chromaffin medullary cells.

The influence on the adrenal medulla of procedures stimulating medullary secretion was examined; for example, adrenals of rats killed during prolonged severe insulin shock were compared with those of normal controls. No certain qualitative differences could be seen. Therefore, areas of phosphatase-positive and -negative tissues were measured planimetrically in sections cut serially. These quantitative studies revealed a statistically significant increase in the volume of the phosphatase-negative tissues of the animals treated with insulin. The volumes of the phosphatase-positive tissues were approximately equal in both groups.

The presence of two kinds of medullary tissues can also be demonstrated with other histochemical techniques[3]. The phosphatase-negative islets are selectively darkened by a short immersion in ammoniacal silver nitrate and they fluoresce brilliantly in ultra-violet light. The significance of the two types of islets is not clear; but both of them have hitherto been seen only in species the adrenals of which contain both *nor*adrenaline and adrenaline.

Further work is in progress.

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Methylation of a Phenolic Hydroxyl Group in the Human Body

In the course of clinical trials of the antithyroxine compound, *n*-butyl 3 : 5-diiodo-4-hydroxybenzoate[1], on patients with thyrotoxicosis, the nature of the substances excreted in the urine was investigated. Practically the whole of the urinary iodine (545 mgm. per diem) was accounted for by the presence of a mixture of 3 : 5-diiodo-4-hydroxy- and, somewhat surprisingly, 3 : 5-diiodo-4-methoxy-benzoic acids in approximately equal proportions.

The acidified urine was extracted with ether, and the ether layer further extracted with sodium hydroxide. Acidification of the alkaline solution precipitated a mixture of iodinated benzoic acids, which, after crystallization from alcohol, melted at 247° (decomp.). This is rather higher than the figure in the literature[2], namely, 237°, for 3 : 5-diiodo-4-hydroxybenzoic acid. The analytical figures (C, 24·4; H, 1·6; I, 62·2 per cent), however, approximated more closely to those for 3 : 5-diiodo-4-methoxybenzoic acid (calc. for $C_8H_6O_3I_2$: C, 23·7; H, 1·5; I, 62·8 per cent) than to those for the hydroxy-acid (calc. for $C_7H_4O_3I_2$: C, 21·5; H, 1·0; I, 65·2 per cent). Repeated recrystallization finally raised the melting point to 261° (decomp.). Wheeler and Liddle[3] report that the methoxy-acid decomposes at 255–256°.

Esterification of the mixed acids with methanol and sulphuric acid gave a mixture of the methyl hydroxy- and methoxy-esters, which were separated by virtue of the solubility of the former in alkali. The methyl 3 : 5-diiodo-4-hydroxybenzoate crystallized from methanol in colourless needles, melting point 168° (in the literature[3], 166–167°) (found: C, 24·2; H, 1·6; I, 62·7; calc. for $C_8H_6O_3I_2$: C, 23·7; H, 1·5; I, 62·8 per cent). A mixed melting point with an authentic sample produced no depression. The methyl 3 : 5-diiodo-4-methoxybenzoate, crystallized similarly, had melting point 95° (in the literature[3], 95°) (found: C, 26·1; H, 1·9; I, 60·6; calc. for $C_9H_8O_3I_2$: C, 25·85; H, 1·9; I, 60·8 per cent). Admixture with an authentic specimen did not depress the melting point.

This work will be discussed more fully elsewhere; but in view of the absence of references in the literature to the methylation of phenolic hydroxyl groups in the animal body (see Lederer[4]), we considered it desirable to place these preliminary results on record.

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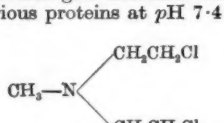
Combination of Nitrogen-15-labelled Nitrogen Mustard with Proteins

The nitrogen mustards readily inactivate certain enzymes[1] and they also react with many other proteins[2], including the components of hæmolytic complement[3]. Although it has been established by various investigators that the amino, sulphydryl, sulphide, carboxyl and pyridine groups of proteins are affected by the action of the nitrogen mustards[4], there appears to be no precise quantitative information about the combination of the mustard with proteins.

We have recently prepared one of the most commonly used nitrogen mustards, methyl *bis*(β-chloroethyl)amine (code No. HN2), labelled with nitrogen-15, and have used this tagged compound (containing 30·4 atoms per cent excess nitrogen-15) to determine the amount of nitrogen mustard which combines firmly with various proteins at *p*H 7·4 and 37°.



Methyl *bis*(β-chloroethyl)amine

Our investigations have shown that considerable amounts of this nitrogen mustard combine firmly with the serum proteins and ovalbumin. The compounds produced contain appreciable amounts of nitrogen-15 even after prolonged dialysis, or precipitation followed by repeated washing with methanol, to remove loosely attached nitrogen mustard and its 'hydrolysis' products (cyclic and other transformation compounds formed by the nitrogen mustards in aqueous solution). The following results of typical experiments with ovalbumin show that the protein treated with nitrogen mustard may contain 3·5

Nitrogen mustard added to 624 mgm. ovalbumin		Molecular ratio* (nitrogen mustard/ovalbumin) in the product	
(Mgm.)	Mol. per mol. of ovalbumin	After dialysis	After precipitation with methyl alcohol
8	2·8	0·5	1·4
12	4·3	1·1	2·4
16	5·7	1·5	3·5

* Assuming a molecular weight of 42,000 for ovalbumin.

nitrogen mustard residues per molecule of ovalbumin, and there is no reason for believing that this is a maximum value.

Part of the nitrogen mustard in the product is apparently not firmly combined with the protein, since it is removed during prolonged dialysis against sodium chloride solution; and this observation is consistent with results we have obtained in immunological studies with proteins treated with nitrogen mustard[5]. These immunological investigations have shown that nitrogen mustard effects a slight but detectable change in the immunological properties of proteins. Thus, the injection of ovalbumin treated with nitrogen mustard into rabbits leads occasionally to the production of antibodies capable of giving slight precipitation of heterologous nitrogen mustard-proteins (for example, horse serum proteins treated with nitrogen mustard). Because of the small amount of precipitate obtained, we have not yet been able to make a complete analysis of it with the heterologous antigen, but precipitates obtained with the labelled homologous antigen have been examined. For example, precipitates obtained with the nitrogen mustard–horse serum protein and nitrogen mustard–ovalbumin antigen–antibody systems contained, respectively, 0·086 and 0·024 atoms per cent excess nitrogen-15. Assuming a nitrogen content of 16 per cent and an arbitrary mean molecular weight of 100,000 for all the proteins, these values correspond to 3·3 and 0·8 nitrogen mustard residues per molecule of total protein (antigen plus antibody).

These results with the serological precipitates, like those with dialysed and methanol-precipitated nitrogen mustard-treated ovalbumin (and serum proteins), show that nitrogen mustard combines firmly with various proteins under physiological conditions of *p*H and temperature.

We are indebted to the Medical Research Council and the British Empire Cancer Campaign for grants which have covered the expenses of this investigation.

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A. Wormall

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London, E.C.1.
May 5.

[1] Thompson, R. H. S., *J. Physiol.*, **105**, 370 (1946–47). Dixon, M., and Needham, D. M., *Nature*, **158**, 432 (1946). Barron, E. S. G., Bartlett, G. R., and Miller, Z. B., *J. Exp. Med.*, **87**, 489 (1948). Cf. also reviews in ref. 2.

[2] For the references see the reviews by Philips, F. S., *Pharmacol. Rev.*, **2**, 281 (1950). Karnofsky, D. A., "Nitrogen Mustards in the Treatment of Neoplastic Disease", a chapter in "Advances in Internal Medicine" (The Year Book Publishers, Chicago, **4**, 1950).

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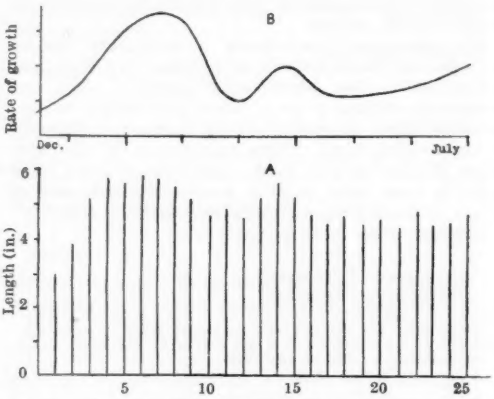
Intraseasonal Growth Variation and Cultivation of Sugar-cane

In my previous work[1,2], I have explained the parabolic growth-variation as noticed in the sizes of the successive leaves, internodes, flowers, fruits and seeds formed from time to time during a season, stressing the importance of this knowledge for the selection of better planting material. The influence of the robustness of seed or planting material on the progeny and yield has been sufficiently stressed by many[3]. I have applied this method successfully to the cultivation of sugar-cane, rice, cotton, mulberry, turmeric and many other plants on an experimental scale, and feel that this could be applied with advantage to the cultivation of most plants.



A, Successive internodes and their lengths; *B*, general growth-curve for the period

The variety of the cane selected was *CO* 419, a hardy variety, introduced into the farms round about Mandya and extensively cultivated. Growth of the cane from time to time was recorded, to have an idea of the growth peculiarities. The accompanying figure is the record of a cane harvested from a standing crop about a year old. It shows the length and number of the successive internodes formed during the several months (*A*) and part of the annual growth-curve (*B*) recorded by me[3]. The agreement is noticed during the earlier period; but this agreement is disturbed as the cane begins to mature, although the growth-vigour of the planting material from this part satisfies the growth-curve of the season. From a standing crop about a year old, canes were harvested and 'setts' were cut from the top and numbered, so that the setts of the same number of all canes might represent the growth region of the same period. These setts, each with three eye-buds, were planted in the experimental plots on October 8, 1947, and the crop of the experimental and the bulk plots was harvested during the last week of November 1948. The method of cultivation for both the plots was the same. The results in the accompanying table will give an idea of the various aspects connected with the different setts.

From these results, it is noticed that on the whole the first two setts are the best for early October planting. The next in order are the third and the fourth. The fifth and the sixth setts are poor because of age, while the other available setts often made

No. of the setts	Average No. of tillers and primaries (after 4 months) per sett	Average No. of canes per sett	Estimated tonnage per acre (approx.)	Percentage of sucrose in juice
I and II	6·1	3·68	38¼	18·96
III and IV	4·7	3·51	36¼	19·22
V and VI	3·3	3·2	31¼	19·01
Bulk	—	3·2	33	19·05

Age of the canes used for cultivation, 1 year approx.; date of planting, October 8, 1947; date of harvesting, November 28, 1948; number of selected setts, 456; number of setts for bulk planting, thousands.

use of by the farmers for planting were the poorest, because they were even older. The same order does not hold good for planting during the other months. The figure will explain this point clearly. The method of selection based on this knowledge will denote the following advantages: (1) economy in the planting material; (2) uniformity in the quality of the yield; (3) maintaining and probably improving the vigour of progeny; (4) increasing the yield per acre.

A detailed paper dealing with this subject will be published later on.

I am indebted to the authorities of the Mysore Sugar Co. for giving the necessary facilities for this work in their factory and farms in Mandya.

C. V. Krishna Iyengar

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June 22.

[1] Krishna Iyengar, C. V., Proc. Ind. Sci. Congr., Pt. 6 (1946).
[2] Krishna Iyengar, C. V., *J. Ind. Bot. Soc.*, **26**, 143 (1947).
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Effect of Light on the Germination of Watercress Seeds

In obtaining data for the two species of watercress for "Biological Flora" accounts, it was found that, whereas the seeds of *Nasturtium officinale* R.Br. would germinate both in the light and in the dark, those of *N. microphyllum* Boenningh. ex Rchb.[1] would only germinate in the light. This has been checked, as is shown below—there were fifty seeds in each Petri dish and they were kept on moist filter paper at laboratory temperature (about 65° F.).

Table 1

	Light		Dark	
	Percentage germination after		Percentage germination after	
	1 week	2 weeks	1 week	2 weeks
N. officinale	84	86	82	82
N. microphyllum	22	60	0	0
N. microphyllum	12	56	0	0

The amount of light required for the germination of *N. microphyllum* seeds appears to be very small. Thus, in one experiment five minutes light given one day after setting up the dishes produced 4 per cent germination in two weeks, and a second exposure of five minutes light given at the end of this two weeks period produced a further 92 per cent germination in the following two weeks. In another experiment the dishes were given single exposures of five minutes light one, two, three and four days after setting up, and the percentage germinations after two weeks were 8, 36, 60 and 58 respectively, the dark control having 0 per cent and the light control 82 per cent germination.

The effect of light on germination can be either by altering some condition of the testa (for example, in relation to permeability to oxygen) or by bringing about some change in the embryo or endosperm (for example, by catalysing the conversion of reserves into soluble substances). In *N. microphyllum* the endosperm can probably be neglected, since in mature seeds it consists of a single layer of cells only. It also appears that the effect of light is on the embryo and not on the testa, since pricking the testas after the seeds had absorbed water did not lead to any germination in the dark, although the pricked seeds germinated as well as the controls when they were later exposed to light.

Another method of deciding for *N. microphyllum* whether the light acts upon the testa or upon the embryo is to utilize three types of hybrid seeds for experiments. This method will also, of course, give some genetical information. These three types of hybrid seed are (*a*) *N. microphyllum* female × *N. officinale* seeds, which have a hybrid embryo in an *N. microphyllum* testa; (*b*) autotetraploid *N. officinale* female × *N. microphyllum* seeds, which have a hybrid embryo in an *N. officinale* testa; and (*c*) seeds obtained by selfing an amphidiploid produced by colchicine treatment of the hybrid *N. microphyllum* × *officinale*—these seeds have both hybrid testas and hybrid embryos. Results for these three types of seed and for autotetraploid *N. officinale* were:

Table 2

	No. of seeds in each dish	Light Percentage germination after		Dark Percentage germination after	
		1 week	2 weeks	1 week	2 weeks
Autotetraploid *N. officinale*	25	20	32	8	28
N. microphyllum × *N. officinale*	38	53	66	0	0
Auto-4 × *N. off.* × *N. microphyllum*	62	37	77	0	0
Amphidiploid *N. microphyllum-officinale*	27	22	59	0	7

Although the percentage germination of autotetraploid *N. officinale* was rather low, it can be seen that it behaves like *N. officinale* itself. The other results suggest first that the effect of light on germination is via the embryo and not via the testa, and secondly that inability to germinate in the dark is dominant to ability. This second conclusion would be expected, since it has been shown that *N. microphyllum* is an allotetraploid species from *N. officinale* and some other species[2].

Results for the occasional seeds produced by the hybrid *N. microphyllum* × *officinale* support the above conclusions. Such seeds will all have hybrid testas, but a segregation of the two types in their embryos would be expected. In an earlier experiment it was, in fact, found that 5·0 per cent of 121 such seeds germinated in the dark and 31·8 per cent of 164 seeds germinated in the light.

Similar results to those reported above for watercress have been obtained by Honing[3] for *Nicotiana*. He found first that the need of light for germination was dominant to the indifferent condition in which

seeds germinate both in darkness and in the light, and secondly that in reciprocal crosses of light-needing and indifferent types the effect could not be due to the testas but must be due to either the embryo or the endosperm.

H. W. Howard
A. G. Lyon

School of Agriculture,
Cambridge.
April 5.

[1] Airy Shaw, H. K., *Kew Bull.*, No. 1, 39 (1947).
[2] Howard, H. W., and Manton, I., *Ann. Bot.*, N.S., **10**, 1 (1946).
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Organic Acids of the Apple Fruit

It has generally been assumed that the only carboxylic acid present in the fruit of Bramley's Seedling apple is malic acid; but in 1949, when examining chromatograms run in *n*-butanol–formic acid–water (40 : 10 : 50 v/v[1]) of methyl alcohol extracts of pulp tissue of young Bramley's Seedling apples, we noted that several spots having an acid reaction to bromophenol blue appeared on the chromatograms.

In addition to a relatively large spot corresponding with malic acid ($R_F = 0{\cdot}49$), there appeared a second well-defined spot ($R_F = 0{\cdot}18$) and traces of a third spot ($R_F = 0{\cdot}07$). It was possible to wash some of the acid ($R_F = 0{\cdot}18$) from the chromatogram and carry out tests on the solution so obtained. The acid gave a strongly positive citrazinic acid test[2], given also by citric and aconitic acids. The R_F value of the unknown acid was, however, quite different from citric acid (0·40), aconitic acid (0·74) and *iso*citric acid lactone (two spots, 0·64, 0·69, probably due to stereoisomerism).

From the R_F values obtained under carefully controlled conditions at 20° C., the R_M values[3] $\left[\log\left(\frac{1}{R_F} - 1\right)\right]$ of the new acid (+ 0·66), citric acid (+ 0·18) and tricarballylic acid (− 0·31) were found to differ by almost equal amounts ($\Delta R_M = 0{\cdot}48$, 0·49) and suggest a stepwise addition of hydroxyl groups to tricarballylic acid. It would appear, therefore, that the new acid might well be a dihydroxy tricarballylic acid.

The acid appeared to decrease in amount as the fruit ripened and also appeared to be present in the pulp of the fruit of peach and plum.

One of us (A. C. H.) has since examined other varieties of English apples for the presence of the new acid. It has been found in much greater quantity in young Worcester Pearmain and young Cox's Orange Pippin apples. In order to study its chemistry, an appreciable amount of the acid has now been obtained from young Worcester Pearmain apples. The fruit was extracted with cold 80 per cent alcohol and the alcohol removed by evaporation. Amino-acids and bases were removed from the resultant aqueous solution by passing it down a column of 'Zeo Karb 215', and the carboxylic acids were absorbed from the filtrate on a column of 'Deacidite E'. Displacement of the acids from this column with 0·1 *N* hydrochloric acid gave several hundred milligrams of the new acid (as the lactone) free from malic acid and chromatographically homogeneous. The chemical characterization of the acid will be described elsewhere.

A. C. Hulme

Ditton Laboratory,
East Malling, Kent.

T. Swain

Low Temperature Research Station,
Downing Street, Cambridge.
April 10.

[1] Lugg, J. W. H., and Overell, B. T., *Aust. J. Sci. Res.*, **1** A, 98 (1948).
[2] Feigl, F., and Anger, V., *Microchemie*, **11**, 35 (1935).
[3] Bate-Smith, E. C., and Westall, R. G., *Biochem. Biophys. Acta*, **4**, 427 (1950).

Formation of Green Pigment in Grasshoppers

The factors which lead to the production of green pigment in grasshoppers are still in doubt. Some authors[1–3] claim that the deposition of green pigment, like that of grey, orange and brown, is determined by the background; others[4–6] have found that the background is without effect. Faure[5] obtained green individuals only when they were fed on growing grass in a humid atmosphere.

Observations carried out in the University of Ankara during 1949 and 1950 support the findings of Faure. Yellow hoppers of *Acrida turrita* were reared in green cages. When fed on growing grass, 69·8 per cent became green; when fed on cut grass changed every other day, 10·9 per cent became green; when fed on dry grass, none became green. If green hoppers were kept in green cages and fed on dried grass, only 21 per cent remained green; whereas if they were fed on growing grass, 78 per cent remained green.

Similar results were obtained with the hæmolymph. The hæmolymph of yellow hoppers collected from dry grassy places is yellowish or colourless, never green. In green hoppers collected from areas of green grass the hæmolymph is green in 90 per cent of them. If the yellow hoppers from the former locality are fed on green grass, the hæmolymph gradually becomes green, and after moulting the integument becomes green. The green pigment thus appears in the blood before it is deposited in the integument.

The green pigment is known to be a combination of a yellow carotene-protein with a blue bile pigment protein[7–9]. The appearance of green individuals depends on the formation of bile pigment. It seems possible that this pigment is derived from the breakdown of chlorophyll and that for some undetermined reason this happens only when the grasshopper feeds on fresh growing grass. It is noteworthy that the excreta contain a large amount of free magnesium in hoppers of both colours.

It is hoped to confirm and extend these results in further laboratory experiments.

Selahattin Okay

Department of Zoology,
University of Cambridge.
April 16.

[1] Chauvin, *Ann. Soc. ent. Fr.*, **110** (1941).
[2] James, *Canadian Ent.*, **76** (1944).
[3] Ergene, *Z. vergl. Physiol.*, **32** (1950).
[4] Przibram, *Arch. Entmech.*, **23** (1907).
[5] Faure, *Bull. Ent. Res.*, **23** (1932).
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[7] Junge, *Hoppe-Seyl. Z.*, **268** (1941).
[8] Okay, *Nature*, **155**, 635 (1945); *Rev. Fac. Sci. Univ. Inst.*, B, **12** (1947).
[9] Goodwin and Srisukh, *Biochem. J.*, **48** (1951).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER, and an ASSISTANT LECTURER, IN THE DEPARTMENT OF CHEMISTRY—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4 (August 17).

ASSISTANT (female) for field experiments on fruit crops for the Plant Pathology, Entomology and Plant Protective Chemistry Sections—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (August 18).

ASSISTANT, Grade B (graduate, preferably with some knowledge of a branch of applied chemistry or of geology) IN THE DEPARTMENT OF CHEMISTRY, a LECTURER IN PHYSICS, and an ASSISTANT TEACHER IN MICROBIOLOGY, NUTRITION AND FOOD ANALYSIS in the DEPARTMENT OF BAKERY AND CATERING—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (August 18).

SCIENTIFIC OFFICER (with first- or second-class honours degree in mechanical engineering) for research and development work on mechanical engineering problems (Ref. R/A); a SENIOR SCIENTIFIC OFFICER (with first- or second-class honours degree in mechanical engineering and at least five years experience in industry and/or research and development work) for development to prototype stage of mechanical mechanisms of an original nature (Ref. R/C.1); a SCIENTIFIC OFFICER (with first- or second-class honours degree in mechanical engineering and two to three years industrial and/or research experience) for work on combustion and heat transfer problems (Ref. R/C.2); an EXPERIMENTAL OFFICER (with pass degree or equivalent and at least four years experience in industry and/or research) with experience in electrical instrument design and electronics control and supervisory equipment (Ref. R/C.3); a SENIOR SCIENTIFIC OFFICER (with first-class degree in agriculture, or first- or second-class honours degree in natural science with postgraduate diploma in agriculture) for department carrying out impartial tests of the performance of agricultural and horticultural machinery under practical conditions (Ref. A/T.1); and a SCIENTIFIC OFFICER (with first- or second-class honours degree in mechanical engineering, and two to three years industrial experience desirable) to work on engineering problems arising during impartial tests of the performance of agricultural and horticultural machinery under practical conditions, and to develop special testing apparatus (Ref. A/T.2)—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds. (August 18).

LECTURERS (Grade I and Grade II) IN THE DEPARTMENT OF CHEMICAL ENGINEERING—The Secretary, The University, Birmingham 3 (August 20).

SCIENTIFIC TECHNOLOGIST, Grade I (with a good general training in chemistry, preferably up to degree standard) at the Coal Survey Laboratory in Nottingham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/360 (August 20).

ASSISTANT (Grade B) TO TEACH GEOGRAPHY for Inter.B.Sc., and an ASSISTANT (Grade B) TO TEACH MATHEMATICS for Inter.B.Sc., O.N.C. mechanical engineering, and also Final B.Sc. and H.N.C., at the Luton and South Bedfordshire College of Further Education—The Borough Education Officer, Education Office, 63–69 Guildford Street, Luton, Beds. (August 25).

ASSISTANT PHYSICIST (with an honours degree in physics) to the Radiotherapy and X-Ray Diagnostic Departments—The Personnel Officer, St. Thomas's Hospital, London, S.E.1 (August 25).

OPERATIONAL RESEARCH posts in the Field Investigation Group of the Directorate of Scientific Control (candidates should have a good honours degree, or equivalent, in science, mathematics or engineering)—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed 22/361 (August 25).

TUTORIAL STUDENTSHIP IN MATHEMATICS—The Registrar, King's College, Strand, London, W.C.2 (August 25).

ASSISTANT LECTURER IN AGRICULTURAL BOTANY, and an ASSISTANT LECTURER IN AGRICULTURAL CHEMISTRY (Dairy Chemistry)—The Registrar, The University, Reading (August 27).

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Leeds 2 (August 27).

DEPUTY MECHANICAL ENGINEER—The Clerk of the Metropolitan Water Board, New River Head, Rosebery Avenue, London, E.C.1, quoting Ref. (T) (August 29).

DISTRICT (FOREST) OFFICERS TO THE FORESTRY COMMISSION (with a university degree in forestry, a university diploma in forestry, or a postgraduate degree in a forestry subject)—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 146/51 (August 30).

LECTURER (Grade II) IN COAL PREPARATION—The Secretary, The University, Edmund Street, Birmingham 3 (August 30).

RESEARCH FELLOW (with the degree of Ph.D., and good experience in research in organic chemistry) to act as leader of a team engaged upon research in the Chemical Constitution of Coal, and a RESEARCH ASSISTANT (with a good honours degree in chemistry) IN COAL CONSTITUTION—The Secretary, The University, Edmund Street, Birmingham 3 (August 30).

ASSISTANT IN THE DEPARTMENT OF MORAL PHILOSOPHY—The Secretary, The University, Old College, South Bridge, Edinburgh (August 31).

ASSISTANT LECTURER IN BOTANY—The Registrar, University College, Cathays Park, Cardiff (August 31).

FOOD TECHNOLOGIST in the Department of Health, Southern Rhodesia—The Secretary to the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (August 31).

LECTURER IN ANIMAL HUSBANDRY—The Registrar and Secretary, The University, Bristol (August 31).

LECTURER (with good qualifications in Chemistry and prepared to specialize on problems connected with the physico-chemical structure of collagen, the chemistry of collagen, or the chemistry of the vegetable tannins), an ASSISTANT LECTURER or LECTURER (with practical experience in Leather Manufacture, especially in leather dyeing and finishing, and able to take charge of an experimental tannery), and a RESEARCH ASSISTANT (with a good honours degree in Leather Chemistry, Chemistry, Biochemistry, or Bacteriology with, preferably, some research experience) IN THE PROCTER INTERNATIONAL LABORATORY—The Registrar, The University, Leeds 2 (August 31).

SCIENTIFIC OFFICERS (with a first- or second-class honours degree or equivalent in physics, electrical engineering, mathematics, mechanical or aeronautical engineering, and capable of undertaking research or development work in general physical problems, electronics, aerodynamics, instrumentation or light mechanisms) at the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.212/51A (August 31).

LECTURER IN BACTERIOLOGY in the Department of Pathology, University College of the West Indies—The Secretary, Senate Committee on Higher Education in the Colonies, Senate House, University of London, London, W.C.1 (September 1).

PLANT PHYSIOLOGIST IN THE DEPARTMENT OF BOTANY, for work with radio-active isotopes—The Registrar, The University, Leeds 2 (September 1).

SENIOR LECTURER or READER IN THE CHEMISTRY OF HIGH POLYMERS in the Department of Textile Industries—The Registrar, The University, Leeds 2 (September 1).

ASSISTANT LECTURERS (2, with qualifications in either the microbiology of dairying, or the biochemistry of micro-organisms) IN THE DEPARTMENT OF MICROBIOLOGY—The Registrar, The University, Reading (September 3).

ASSISTANT LECTURER (honours graduate in chemistry or metallurgy with special interests in physical chemistry) IN METALLURGY—The Registrars, The University, Manchester 13 (September 4).

READERSHIP IN PATHOLOGY AT THE INSTITUTE OF OPHTHALMOLOGY—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 5).

CHEMIST I by the Ministry of Supply in London, for the investigation and assessment of requirements of non-metallic materials for aircraft and associated production, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.544/51A (September 8).

CHEMIST II or CHEMIST III (Metallurgist) at a Ministry of Supply establishment in Lancashire, to assist the Chief Metallurgist in the control of laboratories dealing with development work, experimental heat-treatment problems, and production of electric steel and steel heat-treatment—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.543/51A (September 8).

CHEMIST III/ENGINEER III by the Ministry of Supply in London, for the investigation of requirements for materials used in aircraft production, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.545/51A (September 8).

LECTURER IN CHEMICAL ENGINEERING at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 8).

ENTOMOLOGISTS (with a degree in zoology and a sound knowledge of entomology and botany) to carry out a survey of the tsetse areas of the Sudan and undertake research work—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Entomologist' (September 15).

LECTURER IN CHILD PSYCHIATRY—The Registrars, The University, Manchester 13 (September 15).

LECTURER IN MINERAL DRESSING AND ASSAYING in the Department of Chemical Engineering, University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 15).

LECTURER IN PHYSIOLOGY—The Secretary of University Court, The University, Glasgow (September 15).

CHAIR OF ZOOLOGY—The Secretary, The University, Edmund Street, Birmingham 3 (September 17).

ELECTRICAL ENGINEERS and PHYSICISTS (Senior Scientific Officer grade) (with a first- or second-class honours degree in the appropriate subject, at least three years postgraduate research experience, and a wide knowledge of communications work and H.F., V.H.F. or display techniques for research work associated with design and development of airborne and ground equipments) at the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.159/51A (September 22).

MATHEMATICIANS, MECHANICAL and AERONAUTICAL ENGINEERS at Ministry of Supply headquarters in London: SENIOR SCIENTIFIC OFFICER (Ref. C.441/51A) for administration of bomber aircraft research and development, SCIENTIFIC OFFICER (Ref. C.442/51A) for co-ordinating aerodynamic research work in the Ministry and of research projects at aircraft firms, and a SCIENTIFIC OFFICER (Ref. C.422/51A) for performance assessment of fighter aircraft in connexion with industrial firms' projects—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (September 22).

PHYSICISTS and MATHEMATICIANS at a Ministry of Supply experimental establishment in Essex, for work connected with out-of-door instrumentation: PHYSICIST (Senior Scientific Officer grade) with some mathematical knowledge including statistics or a STATISTICIAN with some interest in experimental procedure to be in charge of a team investigating the performance of weapons, PHYSICISTS (Scientific Officer grade) preferably with some knowledge of experimental range technique and procedure, EXPERIMENTAL PHYSICIST (Scientific Officer grade) with experience of metallurgical techniques, and a MATHEMATICIAN (Scientific Officer grade) with interest in experimental methods and some knowledge of hydrodynamics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.220/51A (September 24).

CHAIR OF MATHEMATICS at Victoria University College, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 1).

SENIOR LECTURER IN THE DEPARTMENT OF CIVIL ENGINEERING, University of Natal—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

TUBE INVESTMENTS RESEARCH FELLOWSHIP in the Department of Engineering Production—The Secretary, The University, Edmund Street, Birmingham 3 (October 31).

DIRECTOR OF THE DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES, Territory of Papua and New Guinea—The Secretary, Department of Territories, Canberra, A.C.T., Australia (December 31).

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Nottingham.

CIVIL ENGINEER in the Department of Works and Hydraulics, Trinidad—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27322/74.

DISTRICT ENGINEER in the Public Works Department, Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, quoting 'District Engineer 4/19 S.T.'.

IRRIGATION ENGINEERS under the Government of Nigeria—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27322/154.

JUNIOR RESEARCH OFFICER (male, with honours degree in chemistry or equivalent) for analytical work, including research on the development of new methods and application of existing methods for special purposes—The Director, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

LECTURER IN FOOD SCIENCE in the Department of Bakery and Confectionery—The Principal, Borough Polytechnic, Borough Road, London, S.E.1.

LECTURER IN THE DEPARTMENT OF MATHEMATICS AND MECHANICS, capable of taking pure and applied mathematics up to final honours standard—Prof. H. Levy, Imperial College of Science and Technology, South Kensington, London, S.W.7.

PHYSICISTS (with a first- or second-class honours degree in physics, or equivalent qualification) to supervise and undertake research work involving the application of physical methods to the study of metals and the control of new metallurgical processes—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

PRINCIPAL METALLURGIST to take charge of a laboratory engaged on research into powder metallurgical techniques of rare metals, SENIOR METALLURGISTS to supervise groups engaged on powder metallurgical research, and METALLURGISTS to undertake research work on the powder metallurgy of rare metals, in the Research and Development Branch, Risley—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, stating post applied for.

RESEARCH DEMONSTRATOR IN MATHEMATICS—The Registrar, University College, Exeter.

SENIOR ELECTRICAL ENGINEER in the Public Works Department, Sierra Leone—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27326/47.

TECHNICAL ENGINEER to undertake fundamental technical work in the application of engineering principles to the design of nuclear reactors and allied atomic energy projects, and to predict the performance of such plants—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

TELECOMMUNICATIONS ENGINEERS and PHYSICISTS (Principal Scientific Officer or Senior Scientific Officer grade) (with a first- or second-class honours degree in physics or telecommunications and upwards of five years experience of research and development in R.F. techniques at centimetric wave-lengths, centimetric radar (preferably for airborne application), servo mechanisms or telecommunication networks and feedback amplifiers) at the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.158/51A.

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British Radio and Television for the World. (Radio Show, Earls Court, London, Aug. 28–Sept. 8, 1951 Booklet.) Pp. 28. (London: Radio Industry Council, 1951.) [225

The Abridged Nautical Almanac for the Year 1952. Pp. 410+xxxii. (London: H.M. Stationery Office, 1951.) 8*s*. 6*d*. net. [245

Fire Protection Association. Technical Booklet No. 8: Spontaneous Heating and Ignition in Stored Palm Kernels. By Dr. J. H. Burgoyne. Pp. 12. (London: Fire Protection Association, 1951.) [245

Colonial Office. Two Studies in Applied Anthropology in Kenya: 1. Agricultural Co-operation by Neighbourhood Groups among the Gusii; 2. Bridewealth Limitation among the Gusii. By Dr. Philip Mayer. (Colonial Research Studies, No. 3.) Pp. 33. (London: H.M. Stationery Office, 1951.) 2*s*. 6*d*. net. [245

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Catalogue of an Exhibition illustrating the History of Pharmacy, held during the Festival Period 4 May–28 September 1951 at the Wellcome Research Institution, 183 Euston Road, N.W.1. (Published for the Wellcome Historical Medical Museum.) Pp. 60+6 plates. (London: Oxford University Press, 1951.) 3*s*. net. [255

Carnegie United Kingdom Trust. Thirty-seventh Annual Report. Pp. viii+49. (Dunfermline: Carnegie United Kingdom Trust, 1950.) [255

Department of Scientific and Industrial Research: Building Research Station. National Building Studies, Bulletin No. 10: External Rendered Finishes for Walls. By G. E. Bessey. Pp. iv+24+9 plates. (London: H.M. Stationery Office, 1951.) 1*s*. 9*d*. net. [255

Manchester Museum. Report of the Museum Committee for the Year 1949–50. Pp. 24. (Manchester: The Museum, 1951.) [255

Sixth Congress of the Universities of the British Commonwealth, 1948. Report of Proceedings. Pp. xxvii+238. (London: Association of Universities of the British Commonwealth, 1951.) 21*s*. [285

Imperial Cancer Research Fund. Forty-eighth Annual Report, 1950–1951. Pp. 40. (London: Imperial Cancer Research Fund, Royal College of Surgeons, 1951.) [285

Pitt Rivers Museum: University of Oxford. Occasional Papers on Technology, 4: Notes on the Prehistoric Metallurgy of Copper and Bronze in the Old World. By H. H. Coghlan. Pp. 131+16 plates. (Oxford: Pitt Rivers Museum, 1951.) 15*s*. [305

Department of Scientific and Industrial Research. Brief Guide to the Research Activities of the Department of Scientific and Industrial Research and the Research Associations. Pp. 56. (London: Department of Scientific and Industrial Research, 1951.) [4

Economic Proceedings of the Royal Dublin Society. Vol. 4, No. 1: The Apple in Ireland; its History and Varieties. By Dr. J. G. Hamilton Lamb. Pp. 63+13 plates. (Dublin: Royal Dublin Society, 1951.) 20*s*. [4

University of Leeds: Department of Coal Gas and Fuel Industries, with Metallurgy. Report on the Session 1947–48. Pp. 20. Report on the Sessions 1948–49 and 1949–50. Pp. 28. (Leeds: The University, 1950–1951.) [4

Readers' Guide to Books on Botany. (Readers' Guide, New Series, No. 11.) Pp. 32. (London: Library Association, 1951.) [5

Council for the Preservation of Rural England, Sheffield and Peak District Branch. Annual Report. Pp. 28. (Sheffield: Hon. Treasurer, Vale House, 1951.) [5

British Institute of Management. Production Management Series, 2: Work Study. By R. M. Currie. Pp. 24. (London: British Institute of Management, 1951.) 3*s*. 6*d*. [5

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Report of the Museum of Applied Science of Victoria, with Statement of Receipts and Expenditure for Twelve Months ended 30th June 1950. Pp. iv+20. (Melbourne: Museum of Applied Science, 1951.) [285

Department of Agriculture, Ottawa. Report of the Director of Science Service for the Year ended March 31, 1950. Pp. 120. (Ottawa: King's Printer, 1951.) [285

East African High Commission: Virus Research Institute. Annual Report, 1950. Pp. iv+32. (Nairobi: Government Printer, 1951.) [285

University of Natal: Wattle Research Institute. Report for 1950. Pp. 36. (Pietermaritzburg: Wattle Research Institute, 1951.) [285

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